The American Midland Naturalist

Devoted to Natural History, Primarily that of the Prairie States

Founded by J. A. Nieuwland, C.S.C.

Contents

Vol. 17 MARCH, 1936 No. 2

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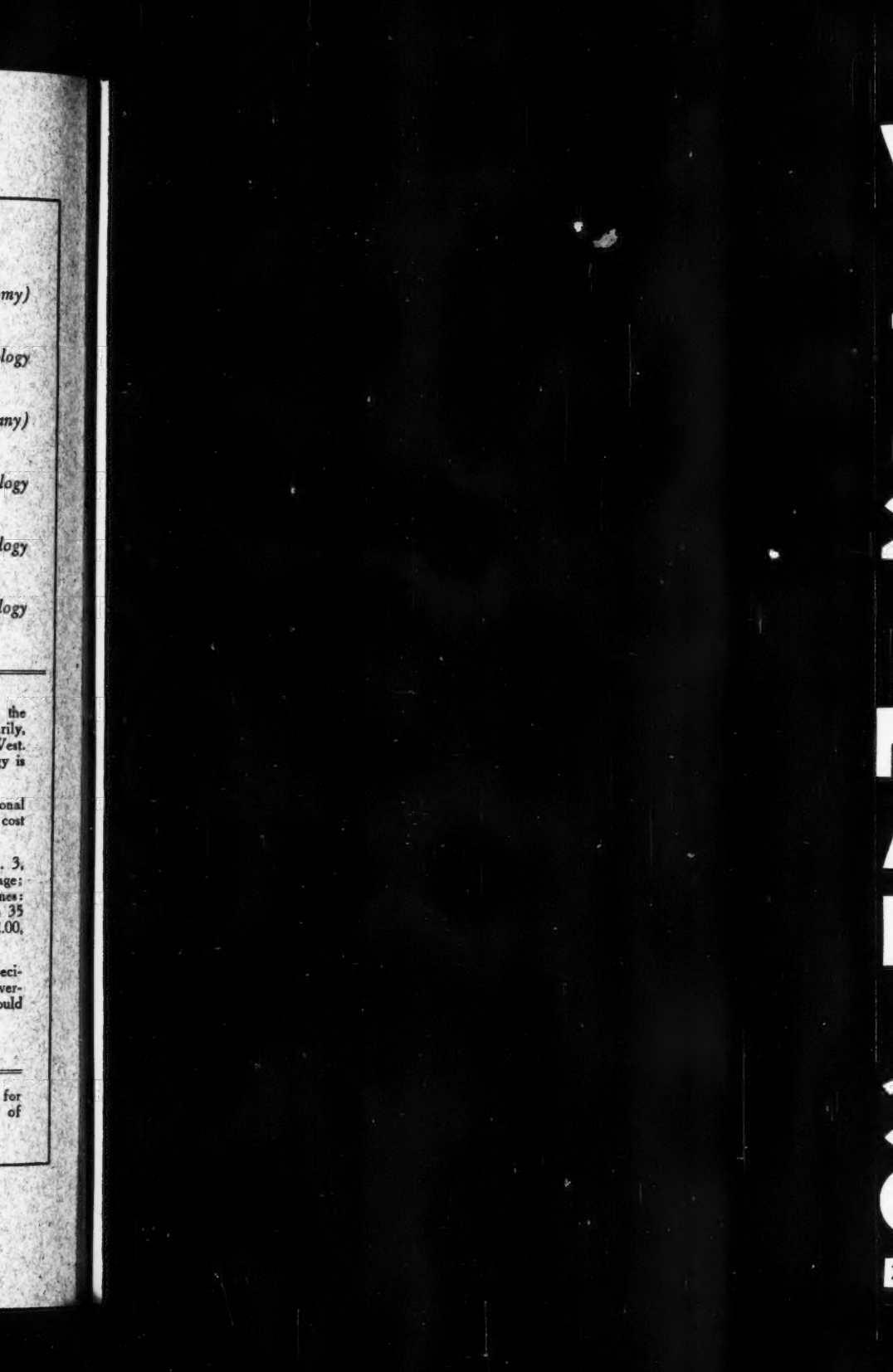
Entered as second-class matter at Notre Dame, Indiana. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on July 3, 1918.



The American Midland Naturalist

Published Bi-Monthly by The University of Notre Dame, Notre Dame, Indiana

VOL. 17 MARCH, 1936 No. 2

The Genus Bazzania in the United States and Canada*†

Margaret Fulford

Bazzania

Bazzania S. F. Gray, Nat. Arr. Brit. Pl. 1:704. 1821 (as *Bazzanius*).
Pleuroschisma Dumort. Syll. Jungerm. 68. 1831.
Herpetium Nees, Naturg. europ. Leberm. 1:96. 1833.
Herpetium, sect. Mastigobryum Nees, Naturg. europ. Leberm. 3:43. 1838.
Mastigobryum Nees, Lindenb. and Gottsche, Syn. Hepat. 214. 1845.

Plants in large tufts or depressed mats, bright green to olive green, golden yellow or brown; stems filiform to robust, the vegetative branches of two sorts, leafy and flagelliform; the leafy branches from the ventral half of a lateral segment, very rarely ventral, forming apparent dichotomies, the angle more or less constant for a species, in most cases less than 90 degrees, the incomplete leaf undivided, acute; cells of the leafy axis showing little differentiation internally, mostly thick-walled, the cortical layer similar to those of the medulla but of shorter cells; the flagelliform branches intercalary, arising mostly singly, in the axils of the underleaves, long, filiform, often branched, the branches intercalary, both lateral and ventral; rhizoids colorless, arising from the leaves of the flagelliform branches, the lower portions of the female bracts, and in some cases from the underleaves: the leaves incubous, alternate (rarely opposite), obliquely inserted, the line of insertion straight to strongly curved in its upper half, distant to imbricated, plane to deflexed, unsymmetrical, ovate to lanceolate, the dorsal base often strongly convex to cordate, the ventral base frequently more or less auricled, the apex in most species truncate, two- to three-toothed (in some four-toothed), or bidentate, or in a few undivided; leaf margins in most cases entire, sometimes serrate, in a few the ventral margin spinose-dentate at the base; the leaf cells quadrate to hexagonal in outline and more or less uniform except at the base where they are larger, or differentiated with 6 to 12 series through the center of the leaf much enlarged, often of a different content, forming a vitta; the trigones very small to well developed and coalescing; the cell-lumen rounded, or angular-rounded to stellate; cuticle smooth to verruculose: the line of attachment of the underleaves transverse, slightly oblique or recurved in some decurrent leaves; the underleaves distant to subimbricated, more or less quadrate, some-

* Contribution from the Osborn Botanical Laboratory.

† A part of a dissertation presented for the degree of Doctor of Philosophy in Yale University.

times cordate, the apex truncate, rounded-entire, to two- to four-toothed or four-lobed, the margin entire to ciliate: dioicous, the male and female branches intercalary, in the axils of the underleaves; male branches few to several on a stem, catkin-like, the bracteoles slightly smaller than the bracts, the bracts in five or more series, ovate, concave, to sub-complicate-convolute; apices truncate, bilobed to bispinose, rarely denticulate to entire; antheridia solitary or in pairs: female branches few to several on a stem; the bracts and bracteoles scarcely differentiated, in four or more series, closely imbricated, the innermost series largest, orbiculate-ovate to ovate-lanceolate, the apex at least somewhat lobed, often two-, three-, or four-divided, the margins crenulate to laciniate-ciliate, cells all alike or differentiated: perianth to 6mm. long, ovoid-cylindrical, terete below, becoming three-keeled in the upper part, contracted at the mouth, of one layer of cells above, one to several layers below, the mouth of three ciliate to dentate lobes, usually contracted: capsule oblong-ovoid, the wall usually of five layers of cells, the outermost layer with brown thickenings appearing as knots along the vertical walls, the innermost layer with brown thickenings arranged as half-rings or bars on the inner tangential walls; capsule stalk with a cortical layer of 16 large cells and a medulla of many smaller cells; spores small, brown; elaters long, slender, bispiral; vegetative reproduction by means of vegetative shoots from caducous leaves and underleaves.

General Discussion of the Species of the United States and Canada

Stephani[1] recognized three species of *Mastigobryum, M. Pearsoni, M. trilobatum,* and *M. tricrenatum* (as *M. triangulare),* as belonging to the flora of the north temperate zone. *M. ambiguum* and *M. denudatum* were included as synonyms of *M. tricrenatum.* He placed all of these species under his section *Grandistipula* which he characterized as having large, not heart-shaped underleaves, which are transversely inserted.

At the present time six species are known to occur in the United States and Canada: *B. Pearsoni, B. trilobata, B. tricrenata, B. nudicaulis, B. denudata,* and *B. ambigua.* Three of these species are limited to the United States and Canada: *B. ambigua* occurs only on the Pacific Coast; *B. nudicaulis* is found only in the higher Appalachian mountains; and *B. denudata,* which is of a wider distribution, is found both in the Pacific coastal area and in the eastern part of the continent. *B. Pearsoni,* according to our present knowledge is a disjunct, since it is known only from a limited area in Ireland and from one station in Alaska. The other two species, *B. trilobata* and *B. tricrenata* are circumpolar and have a wide distribution on both continents.

While *B. Pearsoni, B. nudicaulis,* and *B. trilobata* are subject to variation, they are not nearly so plastic as the remaining species. Often so much variation occurs in the plants of *B. ambigua, B. denudata,* and *B. tricrenata* that correct classification of the plant is difficult. This variation is also present in the European plants of *B. tricrenata* and its allies, but most of the modifications differ at least in degree if not in form from the American plants. The

1 Species Hepaticarum **3**:420. 1908.

variant forms seem to be of two sorts: the simpler type includes those "temporary modifications" which have to do with the adaptations which occur in the individual plant in response to the conditions of the environment, and have been enumerated and discussed adequately by Buch[2,3] in his studies of *Scapania* and *Lophozia;* the other sort seems to be in some degree hereditary and perhaps might be referred to as the various biotypic or genotypic expressions of the comprehensive Linnaean species. Further experimental work with cultures will have to be carried out with the numerous forms before an adequate disposition of them can be made. The various modifications and variations occur chiefly in the habit, leaf form and pigmentation and will be discussed under the respective species.

Little actual evidence is available at the present time which might be used in demonstrating the relationships of the species in question.

B. Pearsoni with its falcate leaves, the highly specialized leaf insertion, the very strongly developed trigones, and the deep brown pigmentation is more nearly like many of the tropical forms. The trends in the development and specialization of the vegetative parts in this species have been along entirely different lines from those in the other species of the temperate zone. The collections show very little variations in different individual plants.

B. trilobata and *B. tricrenata* are the most widely distributed species in temperate North America. Both of these are circumpolar, with *B. tricrenata* perhaps the more widespread. Of the two, *B. trilobata* is the less variable and shows less variation in the plants of different habitats. *B. tricrenata,* on the other hand, is so variable, that its exact relationships with the other species must remain uncertain until controlled experimental work can be carried out on the various expressions of the species. In all probability it developed more or less simultaneously with *B. trilobata,* and from the same ancestor.

B. denudata and *B. ambigua* have many characteristics in common, and on the Pacific Coast, where both species are found, many plants cannot be named with certainty except after a study of the female bracts, in which the two species are quite distinct. Since *B. denudata* is found in both the western and the eastern parts of the continent, it might be assumed that this species is the older of the two, and that *B. ambigua* has developed from it, or else, that both have come rather recently from a common ancestor. If the female branches can be regarded as an example of a conservative structure, this common ancestor could not well have been one of the present species of the United States and Canada. However, some of the more robust plants of *B. denudata* from British Columbia, Alaska, and North Carolina are very similar in appearance to some of the smaller forms of *B. trilobata.*

The caducous habit of both *B. ambigua* and *B. denudata* suggests a rather close relationship between these species and the endemic southern Appalachian

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2 Die Scapanien Nordeuropas und Sibiriens 2. Soc. Sci. Fenn. Commentationes Biol. **3**:5. 1928.

3 Eine neue moossystematische Methodik nebst einigen ihrer Resultate und ein neues Nomenklatursystem. Skand. Naturfoskermode **18**:1. 1932.

species, *B. nudicaulis*, in which this habit is developed to a high degree. The other characteristics of *B. nudicaulis*, however, show similarity to *B. tricrenata*, especially with the small forms of the latter found growing in the mountains. The two species are so similar in general habit, leaf-shape and leaf-insertion that they might easily be confused, were it not for the large underleaves and caducous habit of *B. nudicaulis*.

The suggested interrelationships of the species of the United States and Canada are indicated in Chart I.

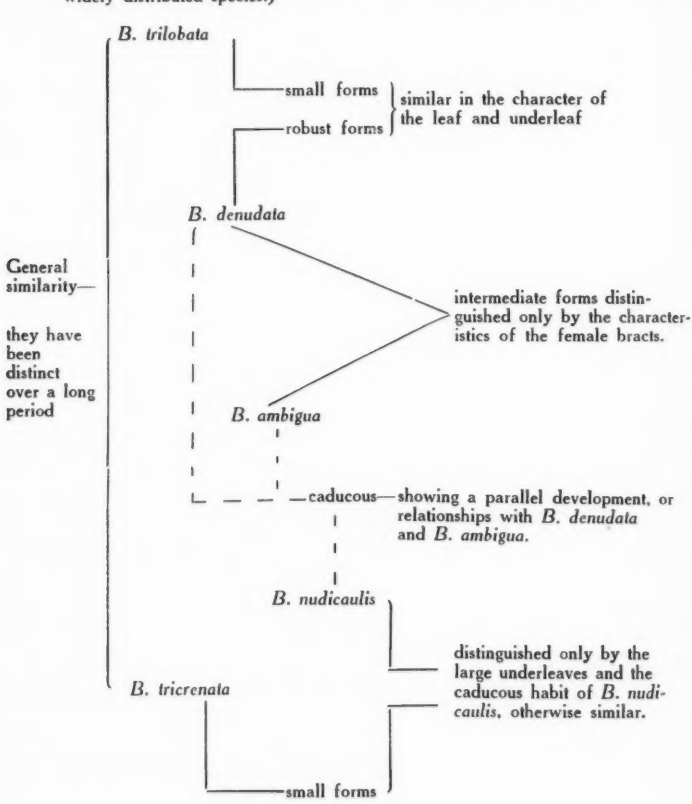

CHART I.

Key to the Species of the United States and Canada

A. Stems with persistent leaves.
  B. Stems slender; leaf cells with large and conspicuous trigones; cell cavity stellate; dorsal base of the leaf strongly cordate and extending across the stem. 1. *B. Pearsoni* p. 389
  B. Stems robust to filiform; leaves with trigones small or absent; cell cavity rounded or hexagonal in outline.
    C. Stems robust; leaves plane, apices transversely truncate, mostly equally three-toothed. 2. *B. trilobata* p. 392
    C. Stems slender; leaves deflexed, apices obliquely truncate, two- to three-toothed, the acroscopic tooth longer. 3. *B. tricrenata* p. 398
    C. Stems filiform; leaves deflexed to nearly plane, mostly distant, acute to two- or three-toothed (small forms). 3. *B. tricrenata* p. 398

A. Stems with at least some of the leaves caducous.
  B. Tufts red-brown to black; stems small, filiform, mostly without leaves and underleaves except near the tips; underleaves large, round-quadrate; leaves mostly acute. 4. *B. nudicaulis* p. 406
  B. Tufts light green to brownish; stems larger; leaves mostly two- to three-toothed.
    C. Stems pale green; leaves mostly two- to three-toothed, plane; most of the underleaves more or less crenulate and with some indication of a tooth or lobe on the lateral margins. 5. *B. denudata* p. 412
    C. Stems pale yellow-green to brownish; leaves more or less deflexed, mostly bidentate; most of the underleaves with scarcely bulging, entire margins. 6. *B. ambigua* p. 419

Bazzania Pearsoni Stephani, Hedwigia **32**:212. 1893.

Mastigobryum Pearsoni Stephani, Spec. Hepat. **3**:476. 1908.
Pleuroschisma Pearsoni (Steph.) K. Müll. Rabenh. Krypt.-Fl. **62**:272. 1912-1916.

Plants in loose tufts, varying in color from yellow-brown to reddish brown: stems slender, to 8cm. long and with leaves to 1.5mm. broad, erect or ascending; in longitudinal section the medullary cells elongate, averaging 160μ long, the cortical shorter, 30μ long, both approximately 15μ wide, the vertical walls uniformly thickened and containing frequent pits, the end walls thin: lateral branches 2cm. or more apart, flagelliform branches sparingly produced: rhizoids colorless, present on the lower portions of some of the underleaves, and on the leaves of the flagelliform branches: the line of leaf insertion in its upper half curved, the dorsal extremity curved downward, forming a hook; the leaves distant to subimbricated, persistent, decurved, very strongly so when dry, broadly ovate, unsymmetrical, mostly 1.2mm. long, broadest at the base, averaging 0.8mm. in width; the dorsal margin convex from a strongly cordate base, extending across the axis and somewhat beyond; the ventral margin concave; the apex decidedly narrower, obliquely truncate, and usually two-toothed, sometimes three-toothed; the teeth variable, two to eight cells long, and two to five cells broad, mostly narrowly triangular, acute, the acroscopic tooth usually extending far beyond the others; the sinuses shallow, acute, to lunulate; the leaf cells with strongly thickened walls containing deep pits which tend to become obliterated with age; trigones brownish, large and pronounced, with con-

vex sides, often in the mature cell separated only by the very narrow pits; the cell cavity stellate; cells of the apical and median portions approximately 18μ x 18μ, and of the basal portion 42μ x 22μ; cuticle smooth to verruculose: underleaves distant to imbricated, orbicular to broadly rounded, mostly 0.46mm. long x 0.4mm. wide, slightly broader than the stem, attached in a straight line, frequently bearing numerous rhizoids at the base; the apex rounded, entire to shortly two- or three-lobed; the lateral margins entire, somewhat undulate, often rounded or cordate at the base: leaves of the flagelliform branches ovate-lanceolate, 0.2mm.-0.3mm. long, somewhat squarrose, convex, the apex mostly sharply two-toothed: female branches sparingly produced, the bracts and bracteoles similar; the outermost ovate-rotundate, mostly 0:5mm. long x 0.4mm. wide, undivided, the margins crenulate, occasionally toothed, the cells variable, thick-walled, the marginal mostly quadrate in outline, the median longer, averaging 26μ x 18μ; trigones pronounced; the innermost bracts somewhat longer (material not mature), the apex divided into two to four acute teeth, the lateral margins crenulate, the cell walls strongly thickened, the cells rectangular in outline, the median averaging 46μ x 18μ; the perianth and male branches not seen.

Habitat:—On shady ledges and tree bases among mosses.

The species is distinguished from the other North American forms by the strongly cordate dorsal base of the leaf, which extends across the stem and somewhat beyond; and by the very thick walls, the large and well-developed trigones, and the stellate lumina of the leaf cells.

Distribution:—This species is referred to as an Atlantic species by Herzog,[4] and is known only from North America, Ireland, and Scotland. The only known record for North America is from Metlakatla, Annette Island, Alaska[5] (Y.)

Type locality:—Killarney, Ireland.

North American Exsiccatae:—None.

4 Herzog, Th. Geographie der Moose. 199, 239. 1926.

5 Evans, A. W. Report on the Hepaticae of Alaska. Bull. Torrey Bot. Club **41**:596.1914.

Fig. 1. *Bazzania Pearsoni* Stephani. 1. Portion of stem, ventral view, x25. 2. Portion of stem, dorsal view, x 25. 3. Underleaves, x25. 4. Leaf, x25. 5. Cells from the dorsal margin of the leaf near the base, x230. 6. Cells from ventral side of leaf near base, x230. 7. Cross-section of stem, x230. 8. Longitudinal section of stem, x230. 9. Female bract of intermediate series, x 115. 10. Female bract of innermost series, x115 (not mature). Nos. 1-10 drawn from specimens distributed by V. Schiffner, Hepaticae europ. exsiccatae, no. 635, collected by Jones and Duncan, on Achill Island, Ireland.

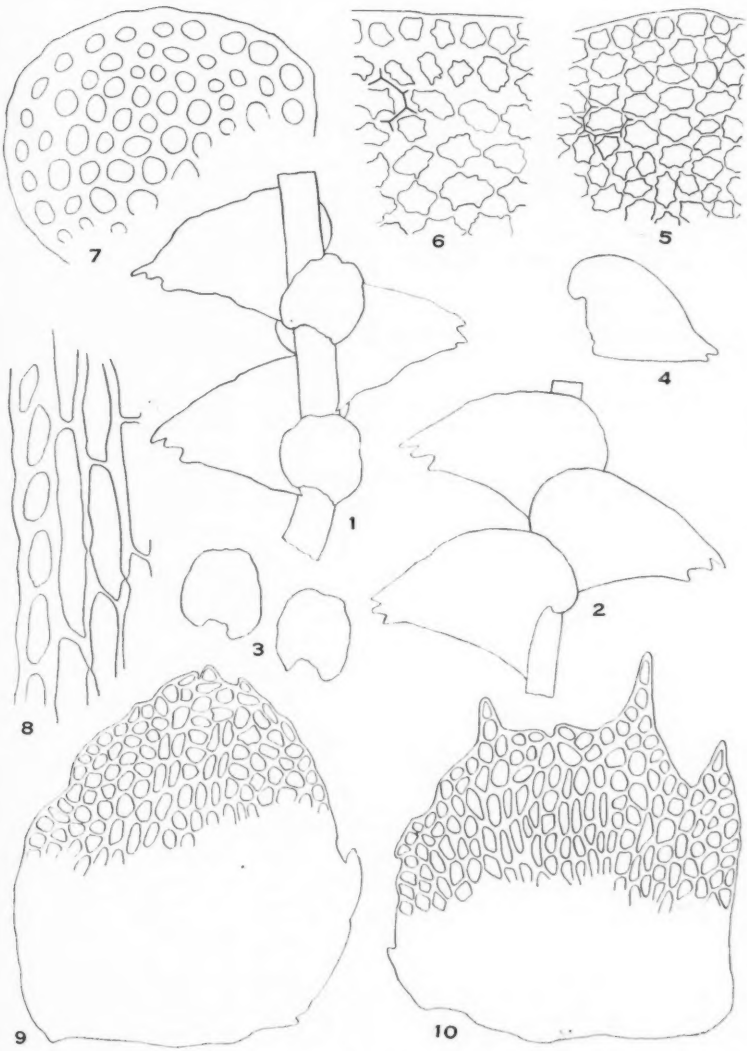

Fig. 1.

Bazzania trilobata (L.) S. F. Gray

Jungermannia trilobata L. Spec. Pl. 1133. 1753.
Jungermannia tridenticulata Michx. Fl. Bor.-Am. **2**:278. 1803.
Bazzania trilobata S. F. Gray, Nat. Arr. Brit. Pl. **1**: 704. 1821 (as *Bazzanius*).
Pleuroschisma trilobatum Dumort. Syll. Junger. 70. 1831.
Herpetium trilobatum Nees, Naturg. europ. Leberm. **3**:49. 1838.
Mastigobryum trilobatum Nees in G. L. & N. Syn. Hepat. 230. 1845.
Mastigobryum tridenticulatum Lindenb. in G. L. & N. Syn. Hepat. 230. 1845.
Bazzania tridenticulata Trevis. Mem. Ist. Lomb. **13**:415. 1877.

Plants in dense mats or tufts, mostly robust, bright green, to dull olive green, becoming light yellow-green in the younger portions: stems stout, 2-10cm, or more long and with leaves 3-6mm. wide, erect or ascending; in longitudinal section the cells elongate, the medullary cells averaging 0.17mm. long, the cortical shorter, both averaging 20μ in diameter; the end walls thin, the vertical walls uniformly thickened and containing pits; lateral branches 5mm. or more apart, diverging at a wide angle; flagelliform branches numerous, long, sometimes branched: rhizoids colorless, present only on the leaves of the flagelliform branches, on some of the underleaves, and on the lower portions of the female bracts: the leaf insertion curved in its upper half; leaves imbricated, plane to slightly convex when seen from above, becoming somewhat deflexed when dry, ovate, unsymmetrical, about 3 mm. long on robust plants, 1.5mm. broad at the base, narrowing somewhat to the transversely truncate, tridentate apex; the dorsal margin strongly convex from a rounded base which covers one-half the stem, the ventral margin straight to slightly concave, the ventral base often more or less auricled; the teeth 5-8 cells long, deltoid, acute to subobtuse, the sinuses shallow, rounded to pointed, the margins entire to slightly undulate; the leaf cells mostly thin-walled but with distinct trigones; cells of the apical portion averaging 27μ x 21μ, of the medium portion, 32μ x 28μ, and of the basal portion, 42μ x 30μ; the cuticle smooth or only slightly verruculose: the underleaves subimbricated, squarrose, attached in a straight line, broadly quadrate-orbicular when well developed, mostly 0.8mm.-1mm. long x 1.4mm. wide, the apex one-fourth to one-fifth divided into four or five, sharply dentate to crenulate, pointed to truncate lobes; lateral margins crenulate, often sinuate-dentate; the leaves of the flagelliform branches 0.2mm.-0.3mm. long, ovate-lanceolate, convex, the apex mostly entire to crenulate, occasionally one- or two-toothed by the projection of the cells: male branches usually several on a stem; the bracteoles small, round-quadrate, mostly 0.4mm. long x 0.57mm. wide, convex from below, bilobed or trilobed; the bracts

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Fig. 2. *Bazzania trilobata* (L.) S. F. Gray. 1. Portion of stem, ventral view, x15. 2. Portion of stem, dorsal view, x15. 3. Underleaves, x15. 4. Leaf, x15. 5. Cells from dorsal margin of leaf, x210. 6. Cross-section of stem, x230. 7. Longitudinal section of stem, x230. 8. Male bract, x115. 9. Male bract, x40. 10. Male bracteole, x115. 11. Male bracteole, x40. Nos. 1-5 drawn from specimens collected at Douglas Lake, Michigan; nos. 8-11 drawn from specimens collected at Schoodic Lake, Maine, by Dr. Evans.

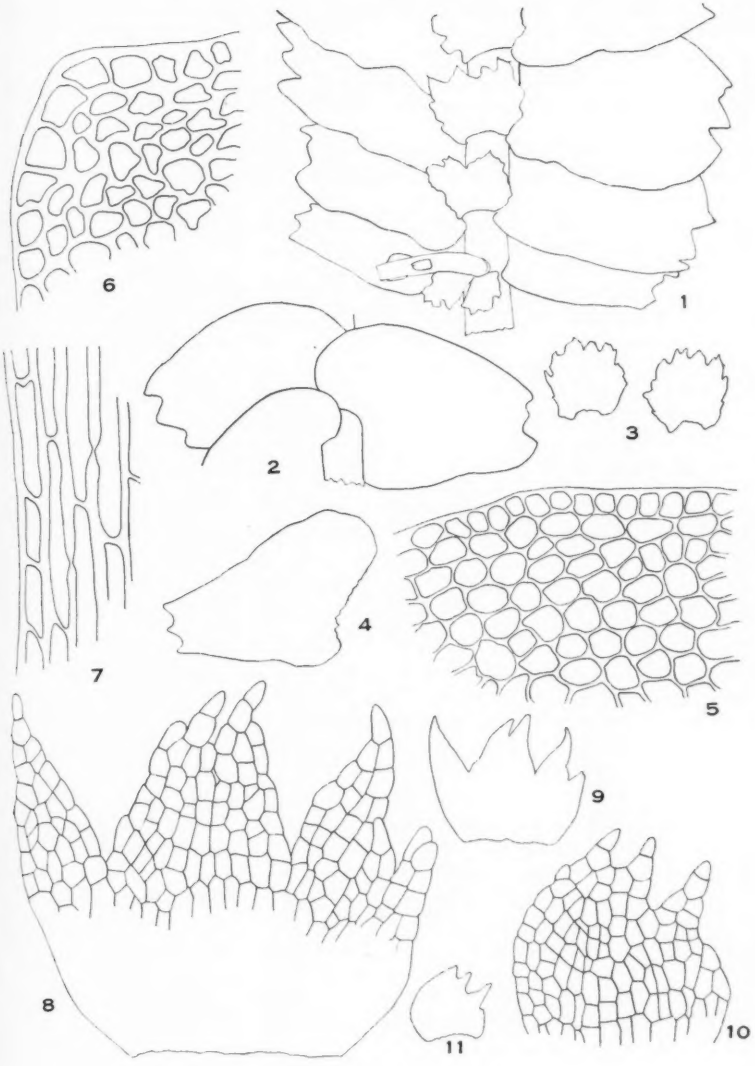

Fig. 2.

larger, mostly 1mm. x 0.8mm., strongly convex from below, the apex consisting of two to four sharp teeth, the lateral margins sometimes toothed; the antheridia occurring singly: female branches solitary to several on a stem; the bracts and bracteoles scarcely differentiated, oblanceolate, the outer mostly 0.52mm. x 0.34mm., the apex and lateral margins ciliate, the cells elongate, the cell-walls thin; the innermost averaging 2.2mm. x 0.75mm., the margins laciniate-ciliate, the apex split into two to four long, slender laciniae with ciliate margins; the cells thin-walled, long-rectangular in outline, averaging 89μ x 32μ: the perianth to 6mm. long, ovoid-cylindrical, contracted at the mouth; the mouth with three short, broad-rounded, dentate to short-ciliate lobes; the cells of two kinds, those of the apical region rectangular in outline, approximately 39μ x 18μ, decreasing in size to the base where they are variable in outline and short: the capsules oblong-ovoid, the wall 5μ thick and of five layers of cells; the cell-walls characterized by dark brown thickenings arranged usually as transverse bands or half-rings, most commonly on the vertical radial walls but also, in addition, on the inner tangential walls, most markedly in the innermost layer of cells, so that the surface next to the spores appears barred; in surface view of the capsule the thickenings appear as knots or lumps (ends of radial thickenings), along the longitudinal walls, more numerous on one wall than on the other in a cell, with the position of the knots reversed in adjacent cells, so that there are alternating rows of comparatively clear cell borders and dark brown knotted bands: the stalk in cross-section composed of a cortical layer of sixteen large cells and a medullary portion of approximately fifty smaller cells: spores 12μ-15μ, brown, with labyrinthine markings: elaters bispiral, brown, 0.2mm. long x 12μ wide, tapering slightly at the rounded ends.

Habitat:—On decaying logs, earth and stone, banks, etc., in woods. Not recorded from limestone regions.

The species exhibits a wide series of variations in size, color and in habit, due mostly, perhaps to differences in the habitats. While these variations have been set apart as distinct varieties or forms in Europe, no attempt has been made to distinguish them in this country, since they grade so freely into one another.

The most luxuriant form of the species grows erect in large tufts in very moist, shaded places. The stems are bright green, 10cm. or more long, and with leaves up to 5mm. broad. They have very few or no lateral branches and grow parallel in the deep tufts—characteristics which are very distinctive in the dried specimens. The flagelliform branches are abundant and well devel-

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Fig. 3. *Bazzania trilobata* (L.) S. F. Gray. 1. Portion of outer surface of capsule wall, x230. 2. Portion of inner surface of capsule wall, x230. 3. Cross-section of capsule wall, x230. 4. Cross-section of sporophyte stalk, x115. 5. Outline of cross-section of perianth, x20. 6. Mouth of perianth, x20. 7. Portion of mouth of section of perianth, x115. 8. Female bract of innermost series, x 40. 9. Portion of top of female bract of innermost series, x115. 10. Female bract of outermost series, x115. 11. Female bract of outermost series, x40. Nos. 1-7 drawn from specimens collected by Dr. Evans at Schoodic Lake, Maine; nos. 8-11 drawn from specimens collected by Miss Lorenz on Mt. Tecumseh, New Hampshire.

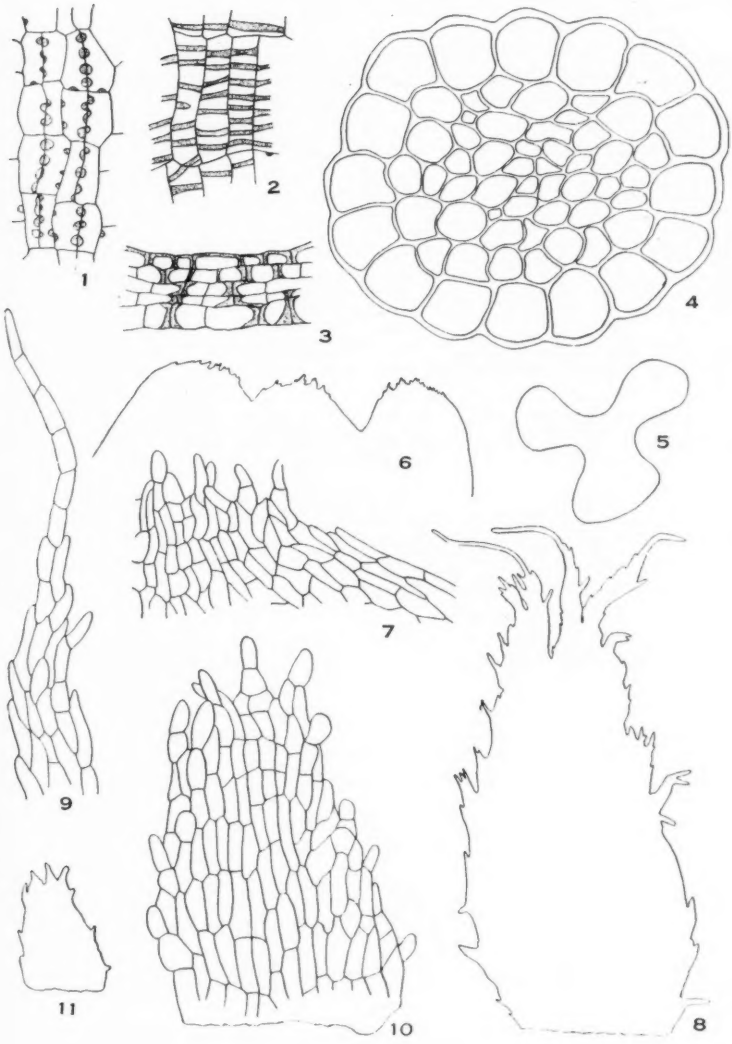

Fig. 3.

oped. The leaves are large and strongly tricrenate and the dorsal base, which is strongly cordate, very often extends across the stem and beyond. The cell-walls are thin with the trigones poorly developed. Nees von Esenbeck[6] called this form *H. trilobatum α grande*, and Schiffner[7] following his ideas has distributed plants with the sort of characters described above, in his Hepaticae europaeae exsiccatae, 658 and 659 as var. *grandis* Nees. K. Müller[8] also recognized the f. *grandis* Nees, but in his form includes both the form *grandis* and the form *typica* of Schiffner. In this country the luxuriant form is found in cool bogs and in deep woods in the mountains. It has been collected in Michigan, Newfoundland, Nova Scotia, Maine and New Hampshire and is to be expected in the most favorable habitats throughout the range.

Plants similar to *grandis* but freely branched, and not so tall or luxuriant are more usual. The stems are bright green, erect, and nearly as broad but do not have the parallel arrangement in the tufts because of the frequent branching. The plants are mesophytic and are to be met with in the woods and in moist places, usually on rich soil, very often in fruit. Schiffner[9] has designated plants of this general habit as *B. trilobata - typica*, while K. Müller regards them as a part of the f. *grandis* Nees, and Nees von Esenbeck[10] considered them as intermediate between *α grande* and *β minus*. It is the most typical form throughout the eastern United States.

Schiffner,[9] following Nees von Esenbeck, has referred to the variety *minor*, plants of this same general habit but shorter than the forms mentioned above. According to him the stems branch freely and may grow erect in short tufts or somewhat depressed over mosses, most frequently over Leucobryum. The plants are always sterile. This modification occurs in this country usually in habitats of strong light, especially in open coniferous forests in the mountains, and is not nearly so frequent as the last. In many instances it is difficult to distinguish from the erect form *typica*, while in the other extreme, it becomes the form designated by Schiffner[9] as f. *ramosa* K. Müller.

In this modification *ramosa* the plants are always depressed, the stems short, and the branches close together. They are found in the more xerophytic habitats, growing on logs, rocks, and on the soil over mosses, etc. The leaves may be bright green but more usually are dull, yellow or olive-green to blackish in color. There is much variation in size and form, for they may be strongly three-toothed, two-toothed and even entire on a single plant. The cell-walls are mostly thick and the trigones large and distinct. *Mastigobryum trilobatum* var. *1* of Austin's Hepaticae Boreali-Americanae no. 78, which corresponds to *M. tridenticulatum* Michx., and the Alaskan specimen noted below, show these characteristics in their lesser degree, while *M. trilobatum* var. 2, no. 79, and many of the plants of the dryer sandstone ledges of Kentucky and West Virginia represent this condition in its extreme. The plants of the *ramosa* habit are not uncommon.

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6 Naturg. eur. Leberm. **3**:49; 56. 1838.
7 Krit. Bemerk. eur. Leberm. **14**:4. 1919.
8 Rabenhorst's Krypt.-Fl. **6**(2):264.1912-1916.
9 Krit. Bemerk. eur. Leberm. **14**:4. 1919.
10 Naturg. eur. Leberm. **3**:50; 56. 1838.

Another form, which is strikingly different from the usual larger plants, is the small xerophytic rock form, collected from only one locality, in which the stems are very short and the leaves and underleaves much reduced. The stem with leaves is 1mm. to 0.5mm. wide, with the leaves distant to closely imbricated. The dorsal bases of the two rows of leaves may be approximate or widely separated, through a twisting of the stem cells, and are rarely imbricated as in the ordinary plants. The leaves and underleaves are much smaller and extremely variable. The apex of the leaf may be two- or three-toothed, acute, or even rounded-entire. The underleaves do not show the strongly sinuate-dentate or crenulate margins seen in the typical form. The cells are smaller, 20μ to 25μ, the cell-walls thick, and the trigones well developed. This form could be referred to *Pleuroschisma trilobatum* var. *depauperatum* K. M. of Europe.[11]

Apparently the distribution of the form in this country is very limited, for it seems to be restricted to the valley of Chestnut Ridge in Monongalia and Preston counties in West Virginia. The following specimens represent this variation. Monongalia Co.: Lick Run, and Decker's Creek near Dellsboro, J. L. Sheldon (Y.); Green, Cheat View, and Kingwood Road near Greer, N. Ammons (A.); Rocky City near Cooper Rock, E. M. Fling (Y.); Preston Co.: Manoun, J. H. Sheldon (Y.); McKinney's Cave, and Masontown, N. Ammons (A.).

Two specimens have been observed in which many of the leaves are caducous. The plants are large, yellow-green to dark brownish green, and normal in every respect except for the caducous leaves. Many of the stems are without leaves throughout much of their length. The underleaves are normal and persistent. One of these specimens was collected on the summit of White Top Mountain, Virginia, in a wet woods (Bryophytes of Virginia, no. 25, A. M. Vail and E. G. Britton, 1892. N. Y.), and the other on the top of Mt. LeConte, Tennessee, in the spruce-fir forest at an elevation of about 6600 ft. (F.).

Under the name *B. trilobata* var. *aquatica* Loitl. Schiffner distributed specimens from Austria, and described them[12] as growing submerged or in places subject to flooding. According to his account the plants are of the size of his f. *typica*, but are less branched and are weaker. The cell-walls, especially those of the underleaves, are much less thickened than in f. *typica*, although the difference is not striking. The plants grow in spongy, upright patches and retain this spongy appearance even in the herbarium material. He has distributed plants of this character as no. 662 of the Hepaticae europaeae exsiccatae. The modification has not been reported in America.

A detailed account of the morphology of the developing stem of the species has been given by Leitgeb.[13]

The species was recorded in this country as early as 1803[14] (as *Junger-*

11 Rabenhort's Kryptogamen-Fl. **6**(2):266. 1912-1916.
12 Krit. Bemerk. eur. Leberm. **14**:6. 1919.
13 Untersuchungen über die Lebermoose **2**:1. Pl. 4. 1875.
14 Michaux, A. Fl. Bor. Am. **2**:278. 1803.

mannia tridenticulata), and has been listed in most of the reports and manuals on Hepaticae of Eastern North America since that time. It is widespread in distribution and is the most common *Bazzania* in eastern United States and Canada.

Distribution:—Europe, Asia and North America.

In North America the species is known from the Pacific Coast region of Alaska—one station on Verdure Creek—and in eastern North America from Labrador and southern Quebec southward to Florida and westward to the Mississippi River and western Ontario. Specimens from Alaska, Labrador, Newfoundland, Cape Breton Island, Nova Scotia, New Brunswick, Quebec, Ontario, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Washington, D. C., Virginia, West Virginia, Tennessee, North Carolina, Georgia, Alabama, Florida, Kentucky, Ohio, Michigan, Wisconsin, and Minnesota are in the Yale University Herbarium.

Type locality:—"Habitat in Suecia, Anglia, Italia."

North American Exsiccatae:—Macoun, Can. Hep. no. 17; Underw. & Cook, Hep. Am. no. 12; Austin, Hep. Bor.-Am. nos. 77, 78 var. 1, 79 var. 2; Haynes, Am. Hep. no. 78.

Bazzania tricrenata (Wahlenb.) Trevis. Mem. Ist. Lomb. **13**:414. 1877.

Jungermannia triangularis Schleich. Cr. exs. Cent. 2 no. 61. 1803 (nomen nudum).
Jungermannia tricrenata Wahlenb. Fl. Carpat. 364. 1814.
Jungermannia deflexa Martius, Fl. Crypt. Erlangensis 135. 1817.
Pleuroschisma tricrenatum Dumort. Syll. Jungerm. 70. 1831.
Pleuroschisma deflexum Nees, Naturg. europ. Leberm. **3**:57. 1838.
Herpetium deflexum α *tricrenatum* Nees. l.c.
Herpetium deflexum α *tricrenatum* α 1 *commune* Nees, l.c.
Herpetium deflexum α *tricrenatum* α 1* *fuscum* Nees, l.c.
Herpetium deflexum α *tricenatum* α 2 *elongatum* Nees, op. cit. 58.
Herpetium β *implexum* Nees, op. cit. 59.
Herpetium β *implexum* β 1 *laxius* Nees, l.c.
Mastigobryum deflexum Nees in G. L. & N. Syn. Hep. 231. 1845.
Bazzania triangularis Lindb. Acta Soc. Sci. Fenn. **10**:499. 1875.
Bazzania deflexa Underw. Bull. Ill. State Lab. Nat. Hist. **2**:83. 1884.
Pleuroschisma triangulare Loeske, Moosfl. Harz 96. 1903.
Mastigobryum triangulare Stephani, Spec. Hep. **3**:475. 1909.

Plants in dense mats or scattered among mosses, mostly medium size, olive to dark green, more or less pigmented with brown; stems slender, 2cm.-8cm. long, and with leaves, 2mm. wide, prostrate, but tending to become suberect; in longitudinal section the cells elongate, the medullary averaging 170μ long, the cortical shorter, to 50μ, both about 20μ in diameter, the vertical walls uniformly thickened and containing frequent pits, the end walls thin: lateral branches 1cm. or more apart and diverging at an acute angle; flagelliform branches numerous, long: rhizoids colorless, present only on the leaves of the flagelliform branches and occasionally the underleaves: the line of leaf

insertion curved in its upper half; the leaves mostly imbricated, sometimes approximate to distant, more or less falcate when well developed, strongly curved around the stem when dry, persistent, roughly ovate-triangular, unsymmetrical, about 1mm. long on well developed plants, and about 0.6mm. broad at the base, narrowing upward to the obliquely truncated, usually two- or three-dentate apex; the dorsal margin strongly convex from a rounded base, extending half-way across the stem; the ventral margin concave; the teeth to 0.01mm. long, broadly to narrowly triangular, mostly acute, unequal, the acroscopic tooth projecting beyond the others, the narrow sinuses deep or shallow, rounded to pointed, margins entire or undulate; leaf-cells with moderately thickened walls and pronounced trigones; the cells of the apical portion averaging 26μ x 22μ, of the median portion 35μ x 24μ, and of the base 41μ x 23μ; the cuticle smooth or slightly verruculose: the underleaves distant to approximate, squarrose, attached in a straight line, broadly quadrate-orbicular, wider than the stem, approximately 0.3mm. long x 0.45 mm. wide, the apex sinuate, entire or one-fourth to one-sixth divided into four crenulate, pointed or truncated lobes; the lateral margins bulging, undulate, usually dentate or sinuate: leaves of the flagelliform branches scale-like, entire or bifid: male branches one to several on a stem; the bracteoles small, round-quadrate, averaging 0.22mm. long x 0.3mm. wide, somewhat convex from below, one-third to one-sixth divided into two to four pointed or rounded teeth, lateral margins mostly entire; the bracts similar, larger; antheridia occurring singly: female branches rare, one to several on a stem; perichaetial leaves not differentiated into bracts and bracteoles, ovate; the outer series mostly 0.4mm. long x 0.35mm. wide, often lobed or toothed at the apex, the lateral margins entire, the cells thick-walled; the intermediate series longer, mostly 0.67mm. long x 0.5mm. wide, the apex two- to four-toothed, the lateral margins crenulate, frequently obscurely dentate, the cells mostly quadrate in outline, thick-walled; the innermost series elongate, averaging 1.5mm. long x 0.95mm. wide at the base, narrowing upward, one-fourth divided into usually two, broad ciliate-dentate teeth, the lateral margins crenulate to ciliate-dentate, especially in the upper half; cells of two kinds, in the apical portion long, rectangular in outline, averaging 59μ x 20μ, thin-walled, in the median and basal portions shorter, averaging 40μ x 30μ, thick-walled: the perianth to 6mm. long ovoid-cylindrical, contracted at the mouth, the mouth of three dentate to short-ciliate lobes, the cells of two kinds as in the innermost bracts; the capsule oblong-ovoid; the capsule stalk and wall as in *B. trilobata*;[15] the elaters mostly 260μ long x 7μ wide, bispiral, bunt at the ends; spores brown, 15μ-20μ, papillose.

Habitat:—In mats or among mosses on soil, logs, tree trunks and rocks, in woods. Not recorded from limestone regions.

This species shows much variation both in plants of different habitats and in plants of the same tuft. Nees von Esenbeck[16] recognized as many as five

15 Müller, K. Rabenhorst's Kryptogamen-Flora **6**(2):263. Fig. 76d. 1912-1916.
16 Naturg. eur. Leberm. **3**:57. 1838.

subdivisions of the first rank (varieties) and seven subdivisions of a lower rank (forms and subforms). These subdivisions have been interpreted variously and his names adopted in entirety or in part by many of the later students. Evans[17] has given an excellent summary of the nomenclatorial history of the species.

Among the earliest records of the species in this country is that of Sullivant who distributed in the Musci Alleghanienses, nos. 252 and 253 (1846), some plants under *Herpetium deflexum* varieties *1* and *2* (probably from North Carolina). He described these plants in Gray's Manual.[18] Later, Austin distributed the species in his exsiccatae, Hep. Bor.-Amer., no. 80 (1873), as *Mastigobryum deflexum*. In 1884, Underwood[19] described it under *B. deflexa*. Röll[20] included it in his list under the name *B. triangularis*, from Weston, Washington, together with a variety *'proliferum'* Steph. from Tacoma, Washington. These specimens have not been examined by the writer. From Canada the species was first listed by Pearson[21] as *B. deflexa*, from Vancouver Island and Alaska, and later by Macoun[22] as *B. triangularis*, with a much extended range including Cape Breton Island and Nova Scotia. In 1923 Evans[23] gave a detailed account of the variability of the species and of the nomenclature and brought up to date the locality records of the species in New England. Later[24] he listed the known stations for the rest of North America. The specimens listed from Virginia and North Carolina are, for the most part, similar in appearance to the poorly developed branches described below or to the very small plants often collected from higher elevations of many of the southern mountains.

Typical plants are readily distinguished. They are deeply pigmented with brown, usually strongly so. The leaves are strongly convex, and twisted

17 Notes on New England Hepaticae 17. Rhodora **25**:76. 1923.
18 In Gray's Manual of Botany, Ed. 2. 702. 1856.
19 Hepaticae of North America. Bull. Illinois State Lab. Nat. Hist. **2**:83. 1884.
20 Röll, Julius. Nordamerikanische Laubmoose, Torfmoose und Lebermoose. Hedw. **32**:399. 1893.
21 List of Canadian Hepaticae, no. 32. Geol. & Nat. Hist. Surv. Canada. 1890.
22 Cat. of Canadian Plants. VII. 33. 1902.
23 Notes on New England Hepaticae 17. Rhodera **25**:76. 1923.
24 Notes on North American Hepaticae 10. Bryologist **26**:58. 1923.

Fig. 4. *Bazzania tricrenata* (Wahlenb.) Trevis. 1. Portion of stem, dorsal view, x25. 2. Portion of stem, ventral view, x25. 3. Underleaves, x25. 4. Leaf cells, dorsal margin, x210. 5. Cross-section of stem, x230. 6. Longitudinal section of stem, x230. 7. Portion of stem from material collected on Roan Mt., N. C., Dr. Blomquist, x30. 8-8a. Portions of a stem from material collected at Hunterville, W. Va., Miss Ammons, x30. 9-9a. Portions of a stem of material collected on Jones Knob, N. C., Dr. Andrews, no. 34, x30. 10-10a. Parts of a plant from material collected on White Top Mt., Va., Vail & Britton, x30. 11. Portion of a stem from material collected on White Top Mt., Va. by Dr. Small, no. 54, x30. Nos. 1-4 drawn from material collected by Dr. Evans at Mt. Monroe, New Hampshire, 1902; nos. 5 and 6 drawn from material collected by Dr. T. C. Frye at Aats Bay, Alaska, no. 935 U. S. Bureau of Soils Kelp Invest. Exp. 1913.

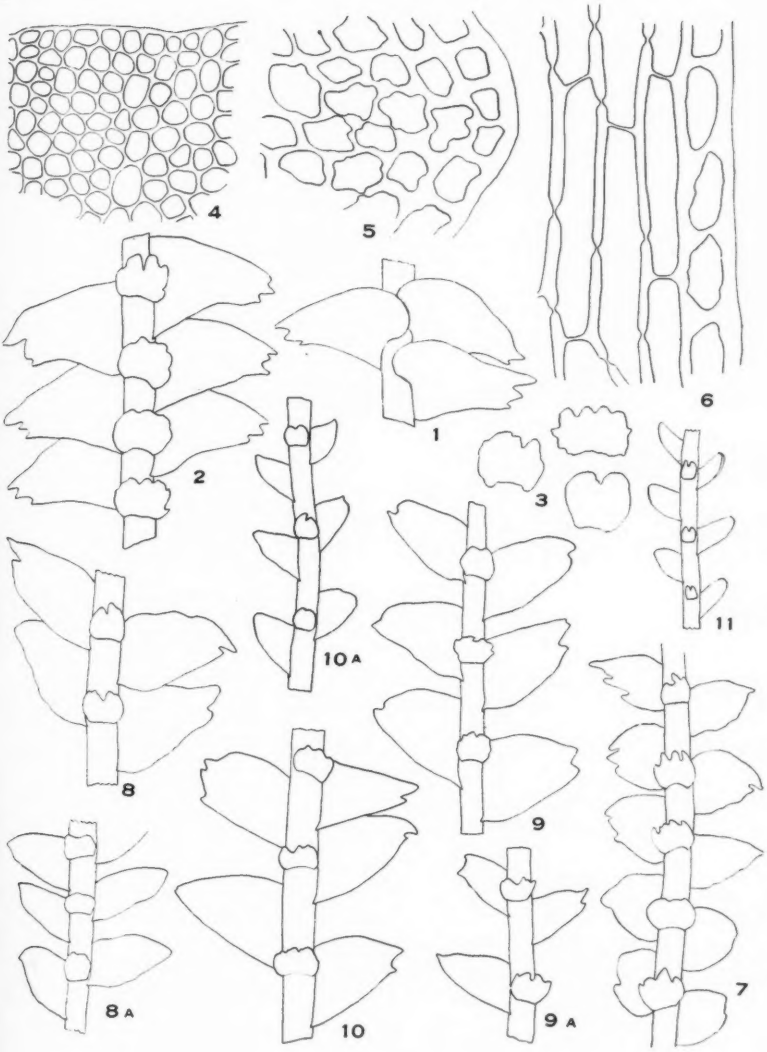

Fig. 4.

around the stem when dry, and tend to be somewhat falcate in the robust forms. They are broad at the base, strongly convex on the dorsal margin near the base, covering one-third to one-fourth of the stem, and decrease in width to the very narrow, obliquely truncate apex, which is two- or three-toothed, with the acroscopic tooth the longest. The underleaves are typically quadrate-orbicular and broader than the stem. The apex is truncated, sinuate, mostly one-fourth to one-sixth divided into two to four, crenulate, pointed or rounded teeth, and the lateral margins are bulging, wavy, and usually one- or two-lobed or dentate. Much variation occurs in the more slender forms, but the deep brown pigment and strong convexity of the leaves should serve to distinguish them. The plants distributed by Sullivant in the Musci Alleghanienses under the name *Herpetium deflexum*, nos. 252 and 253, vars. *1* and *2* represent one of these slender forms.

In contrast to these forms, usually in mountainous regions, poorly developed branches of the larger plants or depauperate plants in the same tuft or in separate patches are decidedly different in appearance. The stems branch profusely, especially near the tips, and the branches very often become flagelliform or have the leaves much reduced. The ventral branches are very often leafy in part or throughout. The leaves are smaller and may be densely imbricated to distant on a single stem. These smaller leaves tend to become symmetrical, and scarcely convex near the dorsal base, and thus do not cover much of the stem. There exists also a wide variation in the forms of the leaf apex. It may be three-toothed as in the usual condition, or acute, or variously two-toothed, or deeply and irregularly divided. Usually some of the typical three-toothed leaves can be found on every stem. The underleaves are proportionately smaller, and are variously toothed or lobed, or even ovate and entire. Small branches of this general appearance were found on a number of otherwise normal plants collected in the White Mountains. In these particular individuals the brown pigmentation was absent throughout much of the plant. They were growing at the mouth of a cave.

The small form becomes more frequent and more distinct southward in the mountainous regions, and in the Southern Appalachians it is quite common. There are often a few of the larger, more typical plants with it, and in many instances the differences between the two forms are so great that it is apt to be regarded as a distinct species. However, material from West Virginia, Virginia, Tennessee, and North Carolina has been examined carefully and compared with the typical *B. tricrenata*, and while many, or in some cases

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Fig. 5. *Bazzania tricrenata* (Wahlenb.) Trevis. 1. Female bract of outer series, x30. 1a. The same, x115. 2. Female bract of intermediate series, x30. 2a. The same, x115. 3. Female bract of innermost series, x40. 3a. The same, x115. 4. Portion of perianth mouth, x115. 5. Portion of tip of perianth mouth, x230. 6-8. Male bracts, x115. 9. Male bracteole, x115. Nos. 1, 1a, 3, 3a, 4, 5, 7, and 9 from plants collected by Dr. T. C. Frye at Sitka Alaska, U. S. Fish Commission, 1894; nos. 2 and 2a drawn from plants collected by Dr. Frye at Aats Bay, Alaska, no. 935 U. S. Bureau of Soils Kelp Invest. Exp. 1913; nos. 6 and 7 drawn from plants collected by Dr. Evans on Mt. Woodun, New Hampshire, 1917.

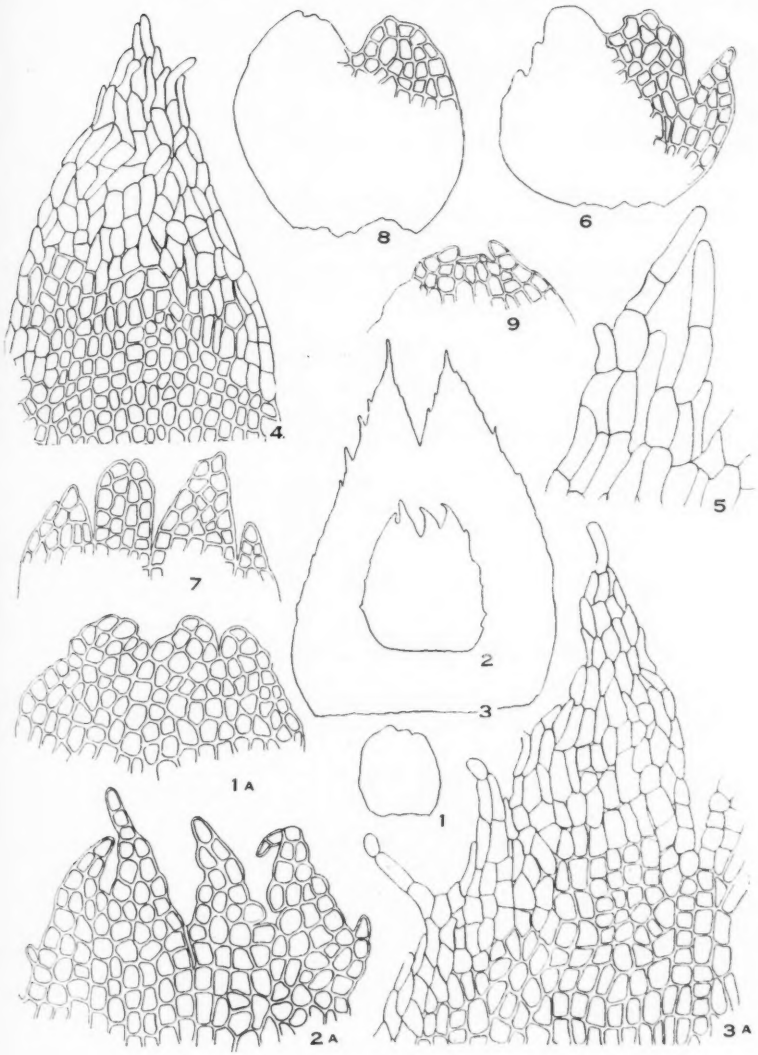

Fig. 5.

most, of the branches are entirely different, other plants and even other parts of the same stem may have large leaves, well within the normal range of size and shape for the typical plants. (See Fig. 4, nos. 8-11).

That the extremes of differentiation are well marked must be admitted, but certainly one must also remember that all gradations from the most robust plants with large, imbricated, three-toothed leaves to the filiform plants with small, distant, acute leaves can be found. While all of these forms cannot be found in the same patch many different forms do occur together, and in most cases these forms overlap as nos. 1, 2, 7-11 of Fig. 4 will show.

The more usual plants of the higher elevations vary in color from bright green to red-brown, and always have a brown pigmentation. They may be very small, often thread-like, or larger, and scattered over mosses or in depressed mats. The lateral branches are 4mm. or more apart and diverge usually at a wide angle. Ventral branches are numerous, often branched and are flagelliform or leafy, in part or throughout their entire length. The leaves are distant and slightly to strongly deflexed. They vary from 0.25mm. to 0.7mm. long, are ovate to ovate-lanceolate, and are obliquely to widely spreading. The apex is usually acute though one finds plants in which many of the two- to three-toothed sort occur. The leaf-cells are somewhat smaller than in the typical plants and the cell-walls are often thicker, but here again, there is much variation; the trigones are small but distinct. The underleaves are small, quadrate, and nearly as broad as the stem. The apex may be entire to lobed or two- to four-toothed.

Many of the plants have poorly developed female branches. The archegonia were not fertilized so that for the most part the innermost series of bracts was not sufficiently developed to be significant, but the outer and intermediate series, from plants of different localities which possessed a wide range of variation in leaf-size and in leaf outline, showed a very similar if not identical form. While these are far from being identical with the female bracts of the well developed plants, they nevertheless show a strong similarity, and the differences are of degree rather than of kind. This is illustrated by a comparison of Fig. 5, nos. 1-3 with Fig. 6, nos. 1-4.

Plants of this sort are very often found growing with the next species, *B. nudicaulis*, also found in the higher mountains.

This striking small form has already been reported by Dr. Evans[25] from high elevations in Virginia and North Carolina. It has also been collected (with female branches) in West Virginia at Hunterville by Miss Ammons; in Virginia, on White Top Mt. by Miss Vail and Mrs. Britton; in Tennessee, on Mt. LeConte, 4500 ft., and Mt. Collins 5800 ft.; and (in the sterile condition), in North Carolina, on Andrews Bald, by Mrs. Taylor.

Distribution:—Europe, Japan, and North America.

In North America the species is known in the northwest from Washington, Idaho, British Columbia, and southern Alaska, and in the east from Quebec

25 Notes on North American Hepaticae 10. Bryologist **26**:58. 1923.

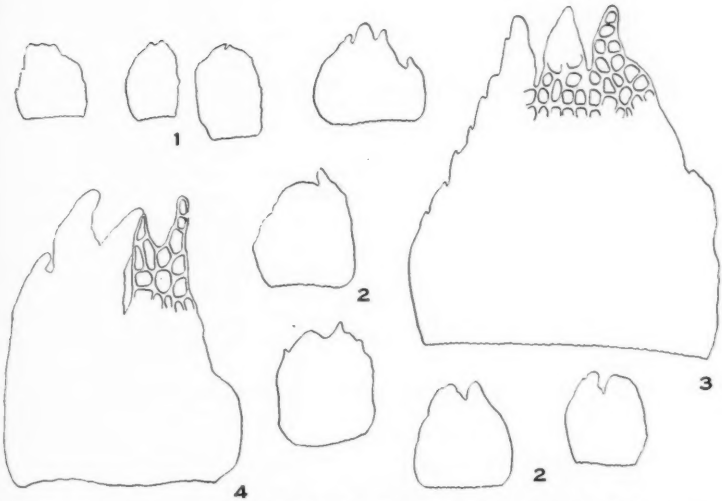

Fig. 6. *Bazzania tricrenata* (Wahlenb.) Trevis. 1. Female bracts of the outer series, x30. 2. Female bracts of intermediate series, x30. 3-4. Female bracts of intermediate series, x115. Nos. 1-4 drawn from plants collected on Mt. Le Conte, Tennessee, 1930.

south to North Carolina, and west to eastern Kentucky and Tennessee. Specimens from Alaska, British Columbia, Gaspe Co., Quebec, New Brunswick, Newfoundland, Maine, New Hampshire, Vermont, Connecticut, and Massachusetts are in the Yale University Herbarium and have already been listed.[26,27] The specimens listed under *B. denudata* from Channel, Newfoundland, collected by Howe and Lang, have been included here. The following additional specimens have been examined: West Virginia, Hunterville, N. Ammons, (Y.): Kentucky, McCreary Co., E. L. Braun (F.): North Carolina, no definite locality, Sullivant (?) (N. Y.); Roan Mt., Blomquist (S.M.S.); Andrews Bald, M. Taylor (Y.): Virginia, White Top Mt., Vail and Britton (N. Y.): Tennessee, Mt. LeConte (F.): Mt. Collins, A. J. Sharp (F.). The species is reported from Oregon[28] and from Washington and Idaho[29] by Clark and Frye.

Type locality:—Europe.

North American Exsiccatae:—Austin, Hep. Bor.-Amer. no. 80, as *Mastigo-*

26 Evans, A. W. Notes on New England Hepaticae 17. Rhodera **25**:76. 1923.
27 Evans, A. W. Notes on North American Hepaticae 10. Bryologist **26**:58. 1923.
28 Bryologist **37**:2. 1934.
29 Puget Sound Biol. Sta. Publ. **6**:125. 1928.

bryum deflexum: Underwood & Cook, Hep. Am. no. 53, as *B. deflexa:* Sullivant, Musci Alleghanienses, no. 252 as *Herpetium deflexum* var.*1*, and no. 253 and *H. deflexum* var. *2*.

Bazzania nudicaulis Evans, Bryologist **26:** 62-65. 1926.

Plants scattered or growing in depressed mats, often without leaves, very small, yellow-brown to red-brown or sometimes almost black: stems filiform, mostly 1cm.-2.5cm. long and with leaves 0.7mm. to 1.5mm. wide; stem cells in longitudinal section elongate, the medullary averaging 0.13mm. long, the cortical shorter, both about 12μ wide, the vertical walls uniformly thickened and containing pits, the end walls thin: lateral branches infrequent, diverging at a wide angle; ventral branches occasional to frequent, mostly flagelliform, sometimes with well developed leaves and underleaves: rhizoids colorless, present only on the scale-like leaves of the flagelliform branches or occasionally on the underleaves: line of leaf insertion mostly straight; leaves distant, plane to somewhat convex, more or less deflexed when dry, obliquely to widely spreading, ovate to ovate-lanceolate, nearly symmetrical, 0.5mm. to 0.65mm. long and 0.3mm. to 0.45mm. wide, often smaller, broadest at the base; the dorsal margin usually rounded at the base, the dorsal and ventral margins somewhat convex; the apex narrowed mostly acute, but frequently rounded or unequally and shortly two- or three-toothed, the sinuses shallow, rounded to acute; leaf-cells mostly thin-walled with the trigones small but distinct; cells of the apical and median portions averaging 20μ x 20μ, of the basal portion 25μ x 22μ; the cuticle smooth to slightly verruculose; the underleaves distant, large, quadrate-orbicular, mostly 0.4mm.-0.45mm. long and wide, exauriculate at the base, the lateral margins usually only slightly bulging, entire, the apex truncate, mostly faintly sinuate or entire, occasionally with two to four short, rounded lobes and lunulate sinuses: leaves of the flagelliform branches scale-like, ovate, acute to bidentate: sexual branches not seen: vegetative reproduction by means of caducous leaves and underleaves.

Habitat:—On sandstone rocks and on trees in tufts or scattered among other bryophytes, in the higher mountains of the southern Appalachian system.

B. nudicaulis is most easily distinguished from the other North Ameriacn species of *Bazzania* by the small size of the plants, the caducous habit, and the very large, round-quadrate underleaves, most of which are often nearly twice as broad as the stem. The caducous habit is very strongly developed in both

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Fig. 7. *Bazzania nudicaulis* Evans. 1. Habit sketch of stem, x 10. 2. Habit sketch of another stem, x15. 3. Portion of stem, dorsal view, x30. 4-5. Portion of a stem, ventral view, x30. 6. Portion of a small lateral branch with reduced leaves and underleaves, x30. 7. Underleaves, x30. 8. Cells from the dorsal margin of leaf, x230. 9. Cross-section of stem, x230. 10. Longitudinal section of stem, x230. Nos. 1, 2, 7, 9, and 10 drawn from the type material; no. 5 drawn from plants collected on Mt. LeConte, Tennessee; nos. 3, 6, and 8 drawn from plants collected on Black Mt., North Carolina, by L. Lesquereux, 1857. (N.Y.)

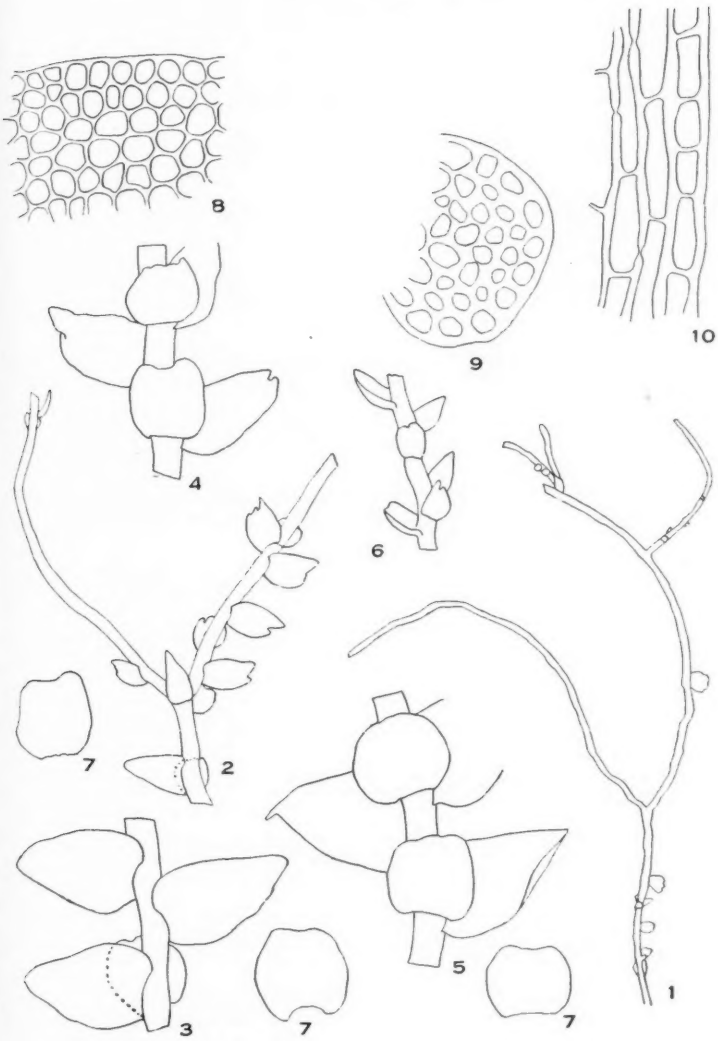

Fig. 7.

the leaves and the underleaves, and stems without leaves except at the tip are most frequently found. For this reason most of the patches appear as interwoven mats of coarse, red-brown to blackish threads. The caducous habit is present in plants with well developed leaves as well as on branches with smaller, deformed leaves. The ventral branches frequently become leafy, and here again, the caducous habit is present.

The leaves and underleaves give rise to new vegetative shoots, often while yet attached, and several examples of this sort have been observed. The new plants arise from single cells, more often near the base of the leaf or underleaf than elsewhere, though many have been observed in the median portion and a few in the apical parts, as is shown in Fig. 8, nos. 15-18. Regeneration of this type, that is by means of adventitious shoots from individual cells is more or less common in a number of North American and European species of Bazzania.

Kreh[30] mentioned the formation of similar branches—under experimental conditions—in *B. trilobata* and *B. tricrenata* from superficial cells of the stem, in the axils of the leaves and underleaves. His figures indicate the course of their development in the earlier stages. Leitgeb[31] has described the development of similar branches from the stems of *Cephalozia bicuspidate* and *Lophocolea bidentata*. Cavers[32] states that occasionally in the Acrogynae the adventitious branches grow out from superficial cells of the stem or from the leaf-cells.

The cell which is to give rise to the branch develops first a protonemal body of the sort referred to by Goebel[33] in his discussion of the four types of spore germination. Buch[34] found that the cells of this protonemal body grow at least for a time by transverse and vertical cell divisions, and then may either give rise to a three-sided apical cell which produces the shoot directly, or one which gives rise to further development of the protonemal body, which in turn produces the apical cell for stem growth later. Very often this stage of protonemal development by a three-sided apical cell is absent. The development of the adventitious branches from cells of the leaf or underleaf in *B. nudicaulis* follows the first mentioned type.

A cell of a leaf or underleaf divides vertically as indicated in Fig. 8, no. 1, and these two cells by a series of two divisions, one transverse and one vertical, form a four-celled body, always on the dorsal side of the leaf (Fig. 8, nos. 2

30 Regeneration der Lebermoose. Nova Acta Acad. Leop.-Carol. **90**:244. Figs. 19-21. 1909.

31 Untersuchungen über die Lebermoose **2**:38. 1885.

32 Asexual reproduction and regeneration in Hepaticae. New Phytol. **2**:11.1903.

33 Über die Jungendzustände der Pflanzen. Flora **72**:18. Pl. 1, Fig. 20. 1889.

34 Physiologische und experimentelle morphologische Studien an beblätterten Lebermoosen 1 und 2. Översikt av Finska Vetenskaps-Societetens Förhandlingar **62**:22. 1919-1920.

and 3). In some cases the vertical division appears not to be formed in the mother-cell. The four-celled body increases in thickness and in length until it becomes four or more cells high. In these larger protonemal bodies there is no indication of growth by a three-sided apical cell as Buch has indicated for a number of species, and all the cells are active in the division. After the protonemal body has reached perhaps 0.5mm. in length, it develops the three-sided apical cell of the new shoot. This always develops at the apical end of the body and evidently from a cell somewhat below the surface, for in the older shoots the protonemal cells appear to form a cup in which the base of the stem is enclosed (see Fig. 8, nos. 6, 8, 9, and 10). The protonemal cells are readily distinguished from the stem cells, for they are rounded and irregularly arranged, while the stem cells are elongate and arranged in rows. The activity of the protonemal cells apparently does not cease with the formation of the new stem, for the number of cells present at the base of a very young stem is usually about half the number in the older shoots as seen in a comparison of nos. 6 and 7 with no. 10 in Fig. 8. Rhizoids from the cells of the protonemal body have been observed in a few instances as in Fig. 8, no. 18. They can arise from cells in any position, indicating that the protonemal body is not dorsi-ventral as is the shoot.

When the plants reach a centimeter or more in length, they readily become detached from the leaf-cell, but in the younger stages, when they or the protonemal bodies are pulled off, the mother-leaf-cell breaks away from the neighboring cells and remains attached to the new plant.

The development of adventitious shoots in some of the European species proceeds in a manner similar to that just described for *B. nudicaulis*. Plants distributed by Schiffner in Hepaticae europaeae exsiccatae, no. 638, as *B. triangularis* f. *densior* from Italy, contained many such shoots. Many of the branches reach considerable length, with numerous rhizoids developed along the ventral side of the stem (see Fig. 8, nos. 15 and 19) before the young plants become detached.

The stem development of the adventitious shoot follows that described by Leitgeb[35] for *M. trilobatum*. At an early stage it consists of seven cortical cells and three medullary cells as indicated in Fig. 8, nos. 13 and 14. By subsequent divisions the number increases until in the mature stem there are a large and not constant number of cortical cells which differ from those of the large medulla only in that they have somewhat thicker walls and are shorter. This is shown in Fig. 7, nos. 9 and 10.

The plants, while similar in appearance to small forms of *B. tricrenata* are easily distinguished from these small forms by the caducous habit of the leaves and underleaves, and the very large, quadrate-orbicular underleaves which are mostly entire or only sinuate at the apex.

Since *B. nudicaulis* is usually found growing with small forms of *B. tricrenata* one might well consider the relationships of the two in the light of

35 Untersuchungen über die Lebermoose **2**:2. 1875.

recent investigations by Buch.[36,37] All attempts to find the stems of the two types on one plant have been unsuccessful. Although no experiments have been attempted with them, it would seem that the two are distinct species; *B. nudicaulis* characterized by very large, nearly entire underleaves, caducous leaves and underleaves, and the production of adventitious shoots; and the small forms of *B. tricrenata* characterized by small, toothed underleaves, and persistent leaves and underleaves. No adventitious shoots have been found on these plants.

Distribution:—Endemic in the higher mountains of the southern part of the Appalachian system.

The following specimens have previously been reported:[38] Virginia, White Top Mt., 5675 ft. J. K. Small—no. 54 in part—1892: North Carolina, high bluffs of Roan Mt., 6000+ ft., A. L. Andrews—no. 65 in part, the type—1919; rocks and tree roots, Grandfather Mt., 5964 ft., P. Schallert—no. 19 in part—1923. All of these specimens showed adventitious shoots from the leaves and underleaves. The following additional specimens have been examined: North Carolina, Black Mt., 6275 ft. (?), Lesquereux, 1850 (N.Y.); Roan Mt., Blomquist, (S.M.S.); Clingman's Dome, L. Anderson, (D.): Tennessee, Mt. LeConte, 4500 ft. and 6590 ft. 1933 (F.), Sharp, 1932 (Y.). These plants also showed the adventitious shoots.

Type locality: High bluffs of Roan Mt., N. C. (over 6000 ft.).

North American Exsiccatae:—None.

36 Die Scapanien Nordeuropas und Sibiriens 2. Soc. Sci. Fenn. Commentationes Biol. **3**:5. 1928.

37 Eine neue moossystematische Methodik nebst einigen ihrer Resultate und ein neues Nomenklatursystem. Skand. Naturfoskermode **18**:1. 1932.

38 Evans, A. W. Notes on North American Hepaticae 10. Bryologist **26**:62. 1923.

Fig. 8. *Bazzania nudicaulis* Evans. 1. Regeneration cell seen from the dorsal side of the leaf; the dotted outline indicates the size of the base of the protonemal body, x230. 2. Very young protonemal body, x250. 3-4. Young protonemal bodies on leaves, x230. 5. An older protonemal body on a leaf, x230. 6-8. Shoot development from the protonemal body; the protonemal cells are rounded, x230. 9. An older shoot with the cup-like protonemal body at the base, x230. 10. A very large protonemal body at the base of an older shoot, x230. 11. A juvenile vegetative branch showing the position of the leaves on the stem, x230. 12. Portion of a juvenile stem showing leaf-insertion, x230. 13. Cross-section of a very young adventitious branch, x230 14. Cross-section of an older adventitious branch, x230. 15. Leaf with an adventitious shoot from the median portion, x85. 16. Leaf with an adventitious shoot near the base, x50. 17. A leaf with two protonemal bodies attached, x35. 18. Underleaf with an adventitious shoot near the base, x85; a rhizoid is present on the protonemal body. 19. Underleaf with an adventitious shoot near the base, x55. Nos. 1, 2, 4, 6, 15, 17, and 18 were drawn from material collected on the top of Mt. LeConte, Tennessee; nos. 5, 7-14 were drawn from the type specimens; nos. 3 and 16 were drawn from material from Black Mt., North Carolina, collected by L. Lesquereux; no. 19 was drawn from plant of a European species collected in the Carinthian Alps, by Dr. Rudolf. (V.)

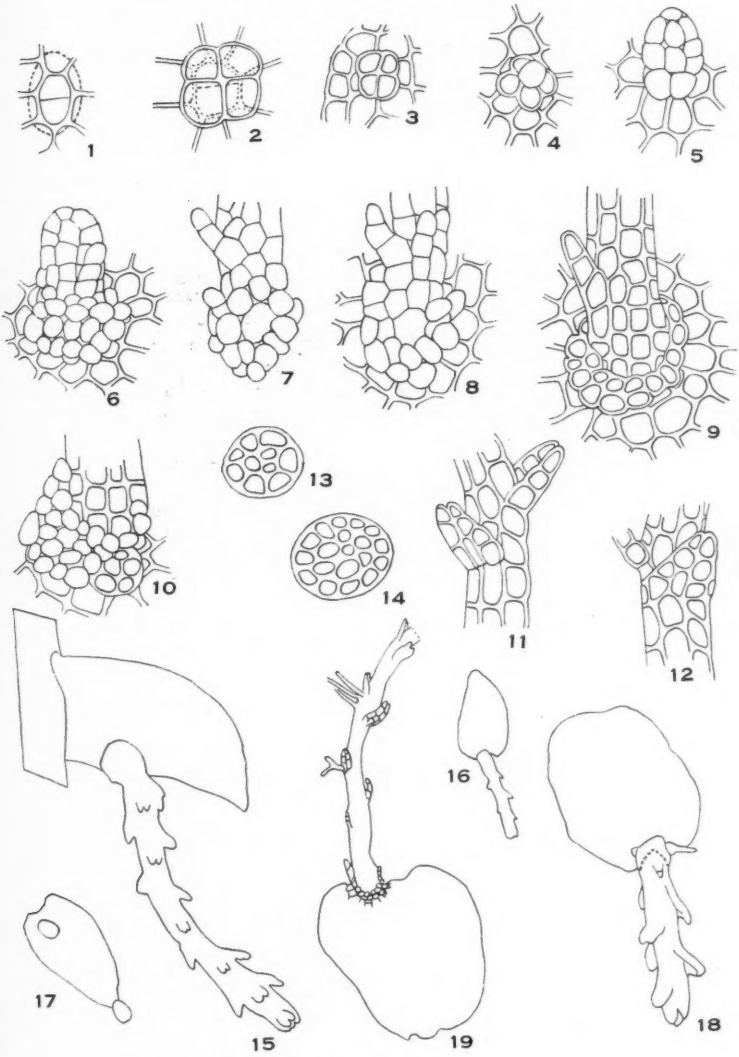

Fig. 8.

Bazzania denudata (Torr.) Trevis. Mem. Ist. Lomb. **13**: 414. 1887.

Mastigobryum denudatum Torr. in G. L. & N. Syn. Hepat. 216. 1845.
Jungermannia denudata Torr. l.c. as synonym, not Nees.
Mastigobryum ambiguum Lindenb. (in part) op. cit. 217. 1845.

Plants scattered or growing in depressed mats, often without leaves, mostly small, dull grayish green, sometimes bright green, not pigmented with brown: stems slender, 1cm.-3cm. long and with leaves mostly 1mm.-2.2mm. wide, prostrate to scarcely ascending; in longitudinal section the cells elongate, the medullary averaging 0.17mm. long, the cortical shorter, and about 0.02mm. in diameter, the vertical walls thickened and containing frequent pits, the end wall thin: the lateral branches 2mm.-4mm. apart, diverging at a wide angle; flagelliform branches rare to abundant, long, sometimes branched, occasionally becoming transformed into leafy branches; rhizoids colorless, sparingly produced, from the leaves of the flagelliform branches, from the female bracts, and in very rare cases from the basal cells of the underleaves: leaves distant to imbricated, the line of insertion straight in the upper half, nearly plane, becoming slightly convex in the outer portion on drying, ovate, unsymmetrical, in typical forms 0.6mm.-0.9mm. long and 0.4mm.-0.6mm. wide, broadest near the base, narrowing to the apex; the dorsal side convex from a straight or rounded base and extending over about one-third of the stem, the ventral margin nearly straight; the apex variable, broad, obtusely rounded to acute, or truncated and two- or three-dentate; the teeth triangular, acute to obtuse, the acroscopic tooth often exceeding the others in length; the sinuses for the most part shallow, rounded to pointed, the margins of the leaves sinuate-undulate: the leaf-cells mostly thin-walled, with small but distinct trigones; cells of the apical portion averaging 27μ x 24μ, of the median portion 36μ x 31μ, and of the basal portion 50μ x 30μ, a vitta not differentiated; the cuticle smooth or slightly verruculose: the underleaves distant, becoming subimbricated near the growing point, attached in a straight line, often strongly squarrose and more or less recurved in the upper portion in well developed plants, quadrate-orbicular, 0.18mm.-0.45mm. long x 0.2mm.-0.5mm. wide, the apex variable, one-fourth to one-fifth divided into numerous crenulate to sinuate teeth, or rounded-entire, or only slightly lobed; the lateral margins bulging, crenulate, mostly sinuate or dentate; the leaves of the flagelliform branches scale-like, about 0.09mm. long, narrow, convex, one- or two-toothed or acute: female branches rare, usually solitary; the bracts and bracteoles scarcely differentiated; the bracts of the outer series ovate, 0.4mm.-0.55mm. long and usually 0.45mm. wide; margins crenulate, the apex entire to dentate by projecting cells, the cells with uniformly thickened walls, the marginal cells small, approximately 30μ x 27μ, those of the median portion larger, rectangular in outline, to 75μ long x 24μ wide; bracts of the intermediate series somewhat larger, the margins entire to crenulate-dentate, the apex dentate from the projecting cells, papillae common, cell-walls thin, cells in the upper portion averaging 33μ x 27μ, those near the base to 50μ x 20μ; the innermost series (not mature) thin-walled, cells as in the preceding series, the margins usually strongly crenulate-dentate, the apical portion rounded, ciliate-dentate, short-ciliate, or

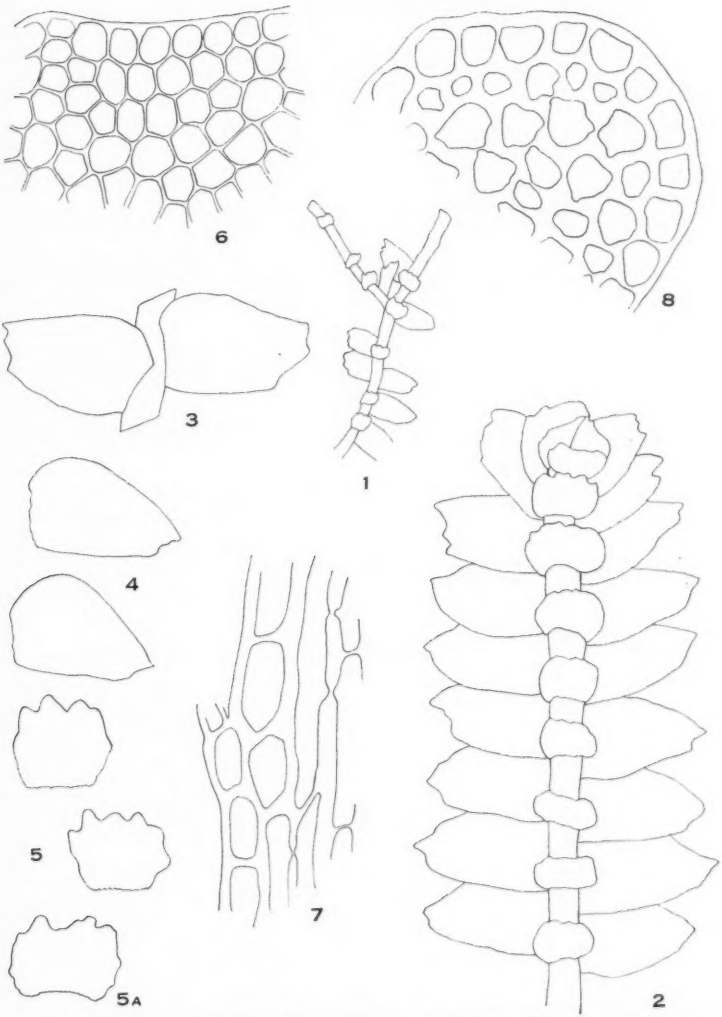

Fig. 9. *Bazzania denudata* (Torr.) Trevis. 1. Portion of stem, ventral view, x10. 2. Portion of stem, ventral view, x25. 3. Portion of stem, dorsal view, x25. 4. Leaves, x25. 5-5a. Underleaves, x25. 6. Cells from the dorsal margin of leaf, x215. 7. Longitudinal section of stem, x230. 8. Cross-section of stem, x230. Nos. 1-8 drawn from plants collected at Ice Gulch, Randolph, New Hampshire, by Dr. Evans.

two- to four-toothed, slime papillae frequent: perianth and male inflorescence not seen: vegetative reproduction by means of caducous leaves.

Habitat:—On rocks, tree bases, or more rarely on rotten logs, in woods, usually in mountainous regions. Not recorded from limestone areas.

A most striking feature of the plant is its caducous habit. The caducous leaves usually occur on some of the plants in every tuft and many of the older stems appear bare or with only occasional leaves except at the growing points. This caducous habit is also found in the underleaves but is less well marked here, so that leafless stems with persistent underleaves are not uncommon. The caducous leaves and underleaves are sometimes much smaller than the ordinary leaves, although in most cases there is no distinction between the two types. Where the caducous leaves are smaller they become detached while quite young. When this is the case the shoot may continue to produce leaves of this type or it may again produce leaves of the ordinary larger size. The caducous leaf under favorable conditions gives rise to a new stem from one of the leaf cells by a process of regeneration of the sort described under *B. nudicaulis*. These new stems are not restricted in their location on the leaf or underleaf, although more of them occur in the basal part than in the median or apical portions.

The plants are so variable that it is difficult to designate a typical condition. On one plant may be found acute, deeply three-lobed, one- or two-toothed, and even entire leaves. The leaves are plane or only slightly convex, even when dry, while those of *B. tricrenata, B. ambigua* and *B. nudicaulis* are more strongly convex when viewed from above. In most cases the color is light green, although occasionally the older portions of the plants of more exposed situations are darker.

In the best developed forms the leaves are broad, even to 0.75mm., the dorsal margin is strongly convex from a rounded base and the apex is rather broad, and divided into three sharp, mostly equal teeth, or is sometimes entire. The ventral margin is usually only slightly convex and may show a bulge near the base as is often seen in *B. trilobata*. The underleaves are large and may be to 0.52mm. broad, with bulging margins. This last character is frequently absent in those plants where most of the leaves are caducous. Some of the robust forms from North Carolina have these characteristics well developed.

The Alaskan specimens mentioned by Evans[39] in his discussion of *B. ambigua*, as seemingly distinct from both *B. tricrenata* and *B. ambigua*, have in this paper been referred to *B. denudata*. They include the following:—Augustine Bay, Frye 578; Port San Antonio, Frye 616, 617, 645 (in part); Sitklan Island, Frye 47; Swift's Cannery, Frye 687; and Verdure Creek, Frye 23 (in part). To these must be added the following, many of which were formerly listed under *B. ambigua:*[40] British Columbia, Skidegate, Queen Charlotte Islands, Spreadborough 83167 (in part) 1910; Ucluelet, Macoun 49,—the plants show characteristics of both species but the bracts are similar

39 Notes on North American Hepaticae 10. Bryologist **26**:59. 1923.
40 l.c. 59.

to those of *B. denudata;* Washington, Merryette Falls, Hamilton, Foster 1905; Pacific Beach, Foster 1450, 1911, Wilby Sound, C. M. Roberts, 1925.

All of these to a greater or lesser degree exhibit characters shown by recent robust and well developed specimens from Mt. Pisgah, and Durham Co., North Carolina. Th stems with leaves are 2mm. or more broad and well developed. The leaf apex is two-toothed to shortly three-toothed, with broad, shallow sinuses, or often just strongly sinuate. The caducous habit is not well developed as in the case of most of the ordinarily developed forms. The underleaves show the most differentiation from the usual type. They are very broad, to 0.6mm, the margins are strongly convex and sinuate to toothed, and the apex is quadrate to ovate-truncate, with two to four short, rounded lobes or teeth, and shallow, rounded to acute sinuses. They are strongly squarrose and have the apices and often the margins strongly to faintly revolute.

These larger western plants produce female branches more freely than do the eastern plants, and a comparison of the bracts of the two show that there is a greater variation in shape, size, and detail of the margins in the bracts of the western specimens, as is indicated in Fig. 10.

With the addition of these western forms the range of the species is greatly extended and *B. denudata* becomes similar in its distribution to *B. tricrenata* and *B. trilobata,* though perhaps less widespread than the latter.

The more usual form in eastern North America is one in which the plants are delicate, pale green, frequently branched, and with many of the leaves caducous. The leaves show all sorts of variations both in size and form of the apex. In most cases they are unsymmetrically ovate with the dorsal margin more or less strongly convex from a rounded base, but occasionally this margin is nearly straight. The apex may be acute or two- or three-toothed, with the teeth all alike or unequal. The underleaves also show a diversity of form. In the more robust plants they approach the size and form of the underleaves of smaller plants of *B. trilobata,* but in the smaller plants they are much reduced and only two- or three-lobed, with the lateral margins entire.

The plants were first collected by Torrey in "America septentrionali prope Novum Eboracum, prope Plainfields in Massachusetts (Hb. Hk.),"[41] and named by him (under *Mastigobryum).* After the publication of the species in the Synopsis Hepaticarum it was redescribed and figured by Lindenberg and Gottsche.[42] Sullivant[43] considered it as probably a form of *Mastigobryum deflexum.* Later Austin[44] in 1873, cited it as a simple synonym of B. *deflexa.* Underwood[45] in 1884 followed Austin's procedure, but in his later work ignored the species completely.[46] In 1888, Stephani[47] reported specimens collected by E. Delamare from Miquelon Island, south of Newfoundland. At the same time he stated that the species was peculiar to North America, but

41 Synopsis Hepaticarum 217. 1845.
42 Species Hepaticarum. Mastigobryum. 7-9. Pl. 1. Figs. 1-4. 1851.
43 In Gray's Manual of Botany, Ed. 2. 702. 1856.
44 Hep. Bor.-Amer. no. 80. Closter, New Jersey. 1873.
45 Hepaticae of North America. Bull. Illinois State Lab. Nat. Hist. **2**:83. 1884.
46 In Gray's Manual of Botany, Ed. 6. 710. 1889.
47 In Delamare, Renauld & Cardot, Fl. Miguelonensis 66. 1888.

he later must have disregarded it completely, since no mention is made of it in his monograph of the genus.[48] Pearson [49] cited the Miquelon Island specimen under *B. denudata* and called attention to Austin's views. Macoun[50] in his catalogue repeated Pearson's statements. Miss Haynes distributed plants of *B. denudata* as American Hepaticae no. 39, which were collected at Little Moose Lake, Herkimer Co., New York, under *B. triangularis*, later corrected to *B. tricrenata*.[51] More recently Evans[52] has made a study of the North American material and reestablished the species as distinct from *B. tricrenata*. He not only redescribed the species but also listed the known specimens. He emphasized particularly the light green color, the wide angle between the stem and the branch, the plane or nearly plane leaves and finally, the caducous habit of the leaves and underleaves. He[53] did not include the European *Pleuroschisma tricrenatum* var. *implexa* (Nees) of K. Müller[54,55] under the species, although he considered it to be very close. He says that while a close approach is apparent, in this latter plant the pigmentation is still present in greater or lesser degree, the caducous habit is less well marked, and the caducous leaves themselves are less highly differentiated.

An examination of much European material showed that while European form possesses many of the characteristics of *B. denudata*, and is quite similar in many ways, the two are not identical. Both of them have caducous leaves and underleaves, are more or less light green in color, and show much variation

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48 Species Hepaticarum, Mastigobryum. **3**: 1908-1909; **6**: 1924.
49 List of Canadian Hepaticae. Geol. & Nat. Hist. Surv. Canada. 9. 1890.
50 Cat. Canadian Plants. VII: 33. 1902.
51 Evans, A. W. Notes on New England Hepaticae 17. Rhodora **25**:91. 1923.
52 Op. cit., 89.
53 Op. cit., 94.
54 Rabenhorst's, Kryptogamen-Flora **6**(2):270. Fig. 80. 1912-1916.
55 Meylan in Beiträge zur Kryptogamenflora der Schweiz **6**(1):240-241. Fig. 167. 1924, has regarded the var. *implexa* (Nees) of K. Müller as a distinct species, *Pleuroschisma implexum* (Nees) Meylan—subspec. nom. nov.—K. Müller states that intermediate forms between the true *P. tricrenatum* and the variety *implexa* are quite frequent; Meylan states that there exists a parallelism of forms between *P. tricrenatum* and *P. implexum*, so that there should be a specific separation of the two.

Fig. 10. *Bazzania denudata* (Torr.) Trevis. 1. Female bract of outer series, x115. 2. Upper portion of female bract of intermediate series, x115. 3. Female bract of innermost series, x115. 4. Another female bract of innermost series, x35. 4a. The same, x110. 5. Another female bract of the innermost series, x35. 6. Female bract of outer series from a plant from the Pacific Coast, x35. 7. Female bract of outer series, x35. 7a. The same, x110. 8. Female bract of intermediate series, x35. 8a. The same, x110. 9. Female bract of the intermediate series, x35. 9a. The same, x110. 10. Female bract of the innermost series, x110. Nos. 1, 2, and 3 drawn from material collected at Ice Gulch, Randolph, New Hampshire, by Dr. Evans; nos. 4, 4a, and 5 drawn from material collected by Miss Brown at Kermbicasis, New Brunswick; nos. 6-10 drawn from material collected by T. C. Frye at Swift's Cannery, Heceta Island, Alaska, no. 687, 1913 (formerly listed under *B. tricrenata* as doubtful by Dr. Evans).

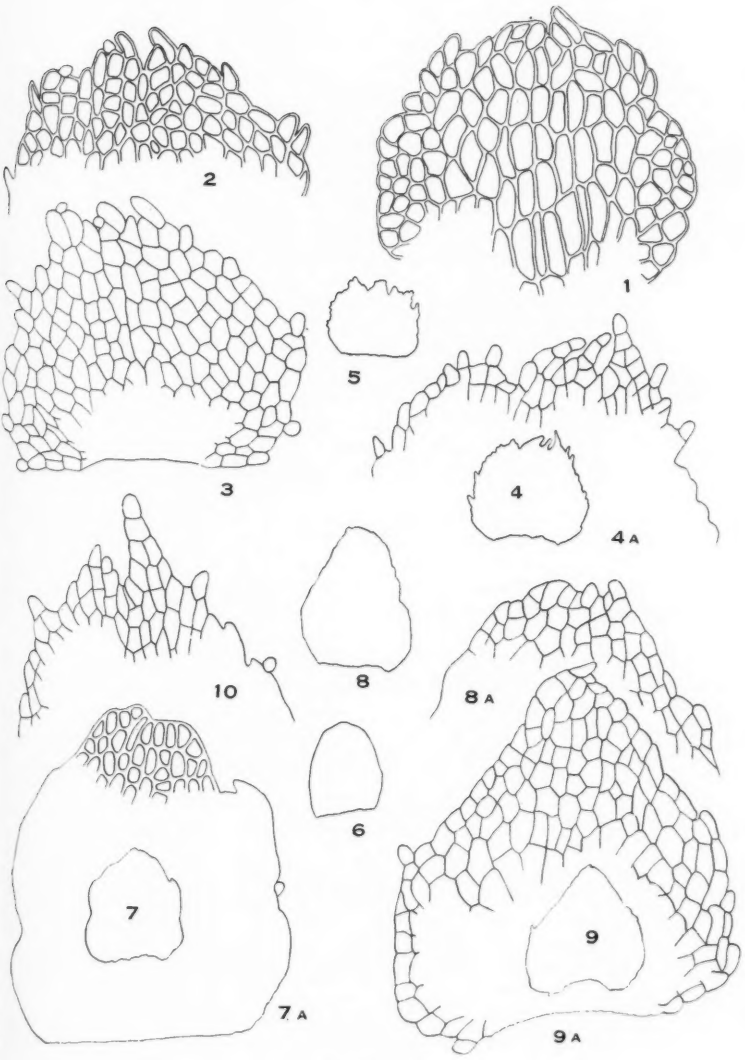

Fig. 10.

in the leaves. However, the light green color of *B. denudata* is uniform throughout the plant, in the old as well as the young portions, while in the European material it is usually confined to the growing region, and the older parts of the stems tend to be olive-green in color and usually have some brown pigmentation, which in the oldest parts is strongly developed.

The leaves of *B. denudata* are, on the whole, larger than those of the European form, are ovate, and the variations occur primarily as changes in size and in the apex rather than changes in the general outline of the leaf. In the European plants, while variation occurs in the shape of the apex, in addition, very often the whole leaf tends to become elongate and nearly linear. In herbarium specimens the European plants have the leaf margins more or less revolute, a character which is not present in *B. denudata.* We have here another example of a situation not uncommon in the field of taxonomy, a condition in which European and North American species of a genus, while quite similar in many respects differ in a few characters.

Male plants have not been observed in *B. denudata,* while they are very abundant in the European material; female branches were not found on this material.

The following European specimens were studied and found to be closely allied but not identical with *B. denudata: Jungermannia deflexa-flaccida* Schleich. from the Salsburg Alps, Funck (B.); Husnot, Hepaticae Galliae, no. 85 (Y.); two specimens from C. Müller, from Baden, 1887 and 1902 (Y.); Dismier, Bryotheca Gallica, no. 197 (Y.); V. Schiffner, Hepaticae europaeae exsiccatae, nos. 638, 639 (Y.); A. Mus. Palat. Vindob. Kryptogamae (N.Y.); Gottsche & Rabenhorst, Hepaticae europaeae, no. 401 (Y.); Massalongo, Erb. Critt. ital., no. 12, 1316 (N.Y.); Herbarium of A. Vigner, two specimens, *M. deflexum,* St. Blaise, Baden, 1868 (N.Y.).

No. 638 of Schiffner's Hepaticae europaeae exsiccatae, *B. triangularis* f. *densior,* from Italy contained numerous stages of developing adventitious branches from the cells of the leaves and underleaves. One leaf contained three well developed shoots. The method of development is identical with that in *B. denudata* and *B. nudicaulis* and has already been described.

The caducous habit, the mostly plane, light green leaves, the straight line of the leaf insertion on the dorsal side of the stem, together with the prostrate form of the stem, the formation of a wide angle between the branch and the stem, and the absence of a pronounced pigmentation will aid in separating this species from the various forms of *B. tricrenata* with which it has so often been confused. The female bracts of the two are quite different (see Fig. 5 and Fig. 10). In *B. tricrenata* the innermost bracts are elongate-ovate, with the apex divided into two or more long, sinuate teeth whose margins are crenulate to ciliate-dentate; the cells are of two kinds, those of the upper portion are thin-walled and long rectangular in outline, averaging 59μ x 20μ, while those of the lower portion are thick-walled and almost quadrate, averaging 40μ x 30μ. In *B. denudata* the innermost bracts are quadrate-ovate, with the apex rounded and merely crenate or sometimes two- to four-toothed, with slime papillae common, and with the margins crenulate to short-ciliate; the cells are all of one kind, thin-walled, rectangular in outline, averaging 33μ x 27μ in

the upper and median portions, and longer and more narrow in the basal portion, averaging 50μ x 20μ.

The species is distinguished from the small, mountain forms of *B. tricrenata* by its larger size, the usually plane leaves, the caducous habit, and the light green color, and from *B. nudicaulis* by its larger size, the light green color, and the smaller, crenulate or toothed underleaves.

Distribution:—Southern Alaska, British Columbia, Washington, and eastern North America from Nova Scotia south to South Carolina and westward to eastern Ohio and Kentucky. Specimens from Alaska, British Columbia, Washington, Nova Scotia, Newfoundland, New Brunswick, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, Virginia, West Virginia, and North Carolina are in the Yale University Herbarium and have been listed[56] (see corrections on page 414). The following additional specimens have been examined: Ohio, Kunkle's Hollow, Hocking Co., Mrs. M. S. Taylor (Y.): Kentucky, Powell Co. (F.); McCreary Co., E. Lucy Braun (F.): Tennessee, Mt. LeConte, A. J. Sharp (F.,Y.); Mt. Collins, A. J. Sharp (F.): North Carolina, Mt. Mingus (F.): Nova Scotia, Halifax, M. S. Brown (Y.).

Type locality:—"In America septentrionali prope Novum Eboracum (a Torrey missa in Hb. Kunzeano)."

North American exsiccatae:—Haynes, Amer. Hep. no. 39, as *B. tricrenata;* Verdoorn, Hep. selectae et criticae, no. 355.

Bazzania ambigua (Lindenb.) Trevis. Mem. Ist. Lomb. **13:** 414. 1877

Mastigobryum ambiguum Lindenberg (in part) in G. L. & N. Syn. Hep. 217. 1845.

Plants in dense tufts or scattered among mosses, sometimes without leaves, mostly slender, usually pale in color, light yellow-green, often showing a brown pigmentation in exposed situations: stems slender, 1.5cm.-2.5cm. long, and with leaves 1mm.-2mm. wide, prostrate, or slightly ascending to suberect in dense tufts; stem cells in longitudinal section elongate, the medullary averaging 0.17mm. long, the cortical shorter and about 20μ in diameter; the end walls thin, the vertical walls uniformly thickened and containing frequent pits; lateral branches 3mm. or more apart, diverging at an acute angle; flagelliform branches numerous, long, sometimes branched: rhizoids colorless, from the leaves of the flagelliform branches, the female bracts, and sometimes from the base of the underleaves: the line of leaf insertion straight in its upper half; the leaves contiguous to imbricated, mostly convex throughout, strongly so when dry, in some the apex revolute, ovate to oblong-ovate, unsymmetrical, 0.54mm.-0.9mm. long, broadest at the base, 0.34mm.-0.6mm.; the dorsal base rounded, the margin convex and extending over one-third to one-half of the stem; the ventral margin approximately straight; the apex narrowed, occasionally acute, more typically broad, truncate and bidentate, with a shallow, lunulate or subacute sinus and short subacute teeth; the cells mostly thin-walled, with pronounced trigones; the cells of the apical portion averaging 23μ x 18μ, of

56 Evans, A. W. Notes on New England Hepaticae 17. Rhodora **25**:89. 1923.

the median portion 30μ x 19μ, and of the basal portion 36μ x 28μ; the cuticle faintly to strongly verruculose: the underleaves distant to imbricated, squarrose, quadrate, 0.3mm.-0.45mm. in length and width, the lateral margins nearly straight and entire, appearing parallel to one another; the apex most typically broad, truncate, with broad lunulate sinuses between the two to four obtuse lobes, or occasionally two- to three-lobed with more acute sinuses: leaves of the flagelliform branches 0.1mm.-0.2mm. long, narrow, convex, rounded to bifid at the apex: male branches to 0.7mm. long, one to several on a stem; the bracts strongly convex from below, round-quadrate, 0.3mm.-0.5mm. long, the apex typically ovate, broadly undulate, sometimes bilobed with a narrow, acute sinus; the bracteoles similar to the bracts, smaller, mostly 0.25mm. long, the apex rounded, truncated, or with two blunt teeth with occasional papillae; antheridia borne singly: the female branches solitary to several on a stem; the perichaetial leaves not differentiated into bracts and bracteoles; the outer series broadly ovate, in length 0.35mm.-0.68mm., in width mostly 0.5mm., the apex entire or broadly sinuate or lobed, the margin crenulate, slime papillae frequent, the lateral margins bulging, undulate, the cells

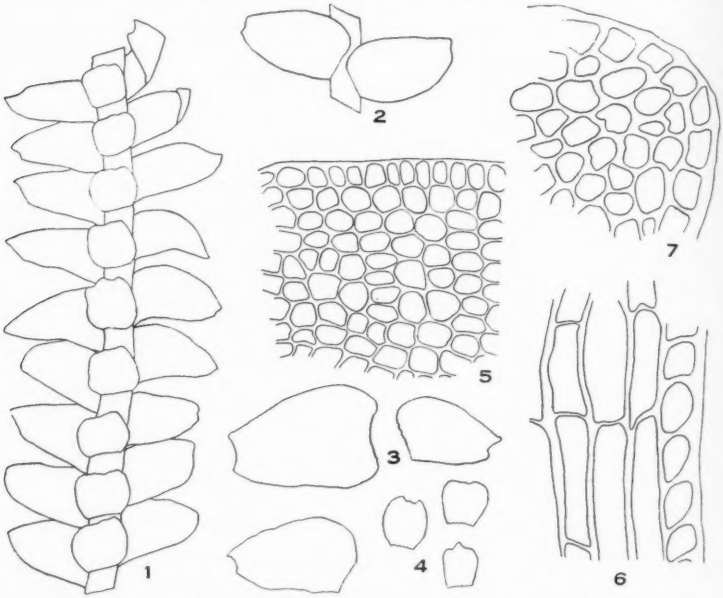

Fig. 11. *Bazzania ambigua* (Lindenb.) Trevis. 1. Portion of stem, ventral view, x25. 2. Portion of stem, dorsal view, x25. 3. Leaves, x25. 4. Underleaves, x25. 5. Cells from the dorsal margin of leaf, x210. 6. Longitudinal section of stem, x230. 7. Cross-section of stem, x230. Figs. 1-7 drawn from plants collected at Monterano, Washington by J. M. Grant, no. 2048.

all alike, thin-walled, averaging 25μ x 18μ; the innermost series quite similar, longer, 1.0mm.-1.3mm. x 0.8mm.-1.2mm., and more fragile; the apex usually of two or three, broad, truncated, crenulate lobes, or rounded, occasionally two- or three-toothed, bearing slime papillae in slight depressions, the cells as in the outer bracts: the perianth to 3mm. long, narrowly ovoid-cylindrical, contracted at the mouth, cells all of one kind, rectangular in outline, averaging 35μ x 18μ wide; the mouth with three short, broadly obtuse, spinulose-denticulate lobes, somewhat contracted: capsule stalk in cross-section, and thickenings in the cells of the capsule wall, as in *B. trilobata;* spores brown, 12μ-15μ in diameter, minutely punctate; elaters with two brown spirals, 200μ-300μ long, 8μ-10μ in diameter, the ends blunt, rounded, slightly tapering: vegetative reproduction by means of caducous leaves.

Habitat:—On tree bases and logs, occasionally on rocks, in woods.

The plant was first described by Lindenberg[57] (as *Mastigobryum),* who based his description on two specimens: "prov. Massachusetts (Asa Gray)" and "ad littora boreali-occidentalia (Hb. Hk.)." The first of these seems to have been *B. denudata;* the second was the closely allied but distinct western species, widely distributed from Idaho to Alaska. In 1851 Lindenberg and Gottsche[58] redescribed and figured the plant, but many of the later writers have ignored it or included it as a synonym of *B. tricrenata.*

Sullivant[59] in 1856 put it in this category as probably a form of that species along with *Mastigobryum denudatum.* Austin[60] and Underwood[61] following Sullivant, also listed it as a synonym. However, Underwood omitted it entirely in his later treatment of the hepaticae for Gray's Manual.[62] Stephani[63] on the statement of Austin, regarded it as a synonym of *B. tricrenata,* and omitted it entirely in his monograph of the genus.[64] Pearson,[65] following Austin's procedure included it under *B. deflexa (B. tricrenata),* while Macoun[66] made no mention of it whatsoever.

In 1923 Evans[67] published a brief history of the species, a record of specimens with localities, and a discussion of its characteristics in contrast to those of the somewhat similar *B. denudata* and *B. tricrenata.* More recently Clark and Frye[68] have recorded it from Washington and Oregon.

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57 Gottsche, Lindenberg & Nees von Esenbeck, Syn. Hepat. 217. 1845.
58 Species Hepaticarum. Mastigobryum, 9. Pl. 9. 1851.
59 In Gray's Manual of Botany, Ed. 2, 702. 1856.
60 Hep. Bor.-Amer. no. 80. Closter, New Jersey, 1873.
61 Hepaticae of North America. Bull. Illinois State Lab. Nat. Hist. **2**:83. 1884.
62 Gray's Manual of Botany, Ed. 6. 1889.
63 Hepaticarum species novae vel minus cognitae 8. Hedwigia **25**:239. 1886.
64 Species Hepaticarum. Mastigobryum **3**: 1908-1909; **6**: 1924.
65 List of Canadian Hepaticae 32. Geol. & Nat. Hist. Surv. Canada. 1890.
66 Cat. Canadian Plants. VII: 33. 1902.
67 Notes on North American Hepaticae 10. Bryologist **26**:59. 1923.
68 Clark, Lois and T. C. Frye. Liverworts of the Northwest. Puget Sound Biol. Station **6**:124. 1928.

The plants are variable both in size and in appearance and are, under some conditions, difficult to distinguish from *B. denudata*. Well developed specimens of the two can readily be separated. In *B. ambigua* the underleaves, while of the size and general appearance of *B. denudata*, have scarcely bulging, entire, lateral margins which are nearly parallel, and apices which are usually two-, three-, or four-lobed. The underleaves of *B. denudata* have bulging lateral margins which are usually sinuate or toothed, and apices with two to four sinuate teeth or lobes. In poorly developed plants of *B. ambigua* the underleaves tend to become convex and sinuate on the lateral margins, while in the poorly developed forms of *B. denudata* they tend to become straight and entire. The leaves of *B. ambigua* for the most part, tend to be more or less transversely truncated and broad at the tips, with the two short teeth separated by a shallow sinus, while those of *B. denudata* are obliquely truncated, and blunt or acute, to three-toothed, with mostly subacute sinuses.

Unfortunately both species show much variation and there are many plants which show a combination of the above characters in such a way that they are difficult to name. In the cases of this sort plants having many of the underleaves with straight and entire lateral margins, and some bidentate leaves have been considered as *B. ambigua*, and plants having many of the underleaves with bulging, sinuate or toothed margins have been considered *B. denudata*. When female bracts are present the two can be distinguished by these, as a comparison of Figs. 10 and 12 show.

While similar in many respects to *B. tricrenata* with which it is often found growing, it can be distinguished by the presence of caducous leaves, by the broad, usually two-toothed leaf apices, the straight line of the leaf insertion on the dorsal side of the stem, and the entire lateral margins of the underleaves. The leaves of typical *B. tricrenata* are persistent, the apices are narrow and unequally three-toothed, the leaf insertion is curved on the dorsal side of the stem, and the lateral margins of the underleaves are crenulate and often sinuate to dentate. The brown pigmentation is absent or only slightly developed in *B. ambigua*, while in *B. tricrenata* it is developed to a marked degree. The female bracts of the two species are entirely different. In the smaller forms of *B. tricrenata*, the smaller size of the plants, the darker green color, and the distant, poorly developed and variously toothed leaves are quite different and distinct from even the poorly developed forms of *B. ambigua*. The small forms of *B. tricrenata* have not been reported from the western part of North America.

Fig. 12. *Bazzania ambigua* (Lindenb.) Trevis. 1. Female bract of intermediate series, x115. 2. The same, x40. 3. Female bract of innermost series, 115. 4. The same, x40. 5. Another female bract of innermost series, x40. 6-7. Male bracts, x115. 8-9. Male bracteoles, x115. 10. Portion of mouth of perianth, x115. Nos. 1, 2, 3, 4, 5 and 10 drawn from plants collected at Monterano, Washington, by J. M. Grant, no. 2048; nos. 6, 7, 8 and 9 drawn from plants collected at South Bend, Washington, by T. C. Frye, no. 2040.

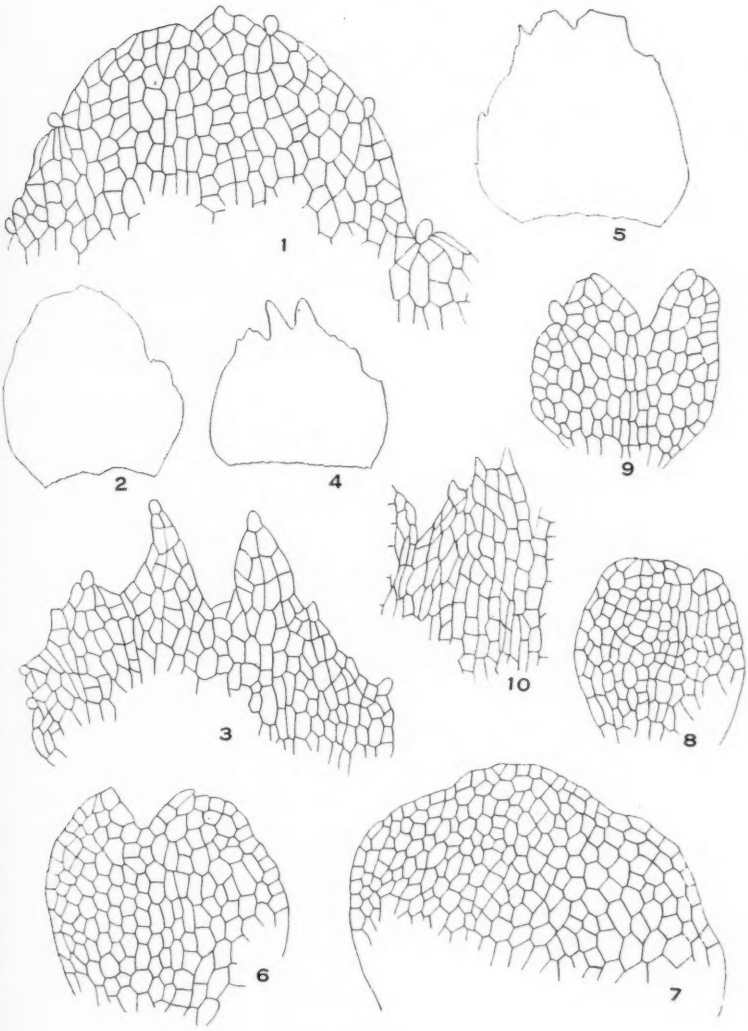

Fig. 12

Distribution:—Northwestern North America along the Pacific Coast from Alaska to Oregon; a Pacific species.

Specimens from Alaska, British Columbia, Washington, and Oregon are in the Yale University Herbarium and have been listed[69] (see corrections under *B. denudata* on page 414).

Type locality:—"In Americae ad littora boreali-occidentalia (Hb. Hk.)."

North American exsiccatae:—Macoun, Canadian Hepaticae, no. 16. as *B. deflexa* (doubtful).

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69 Evans, A. W. Notes on North American Hepaticae 10. Bryologist **26**:59. 1923.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the kindness of all who have loaned types and other valuable material for study. The following abbreviations have been used to designate the location of specimens in citation under the individual species: A., Herbarium of Miss N. Ammons, West Virginia; D., Herbarium of Duke University, North Carolina; F., Herbarium of the writer; H., Cryptogamic Herbarium of Harvard University; N. Y., Herbarium of the New York Botanical Garden; S.M.S., Herbarium of the Sullivant Moss Society; V., Herbarium of the Natural History Museum, Vienna; Y., Herbarium of Yale University including the private collection of Dr. A. W. Evans. The Lloyd Library at Cincinnati has been especially cooperative in the loan of valuable books.

To Dr. A. W. Evans who has given much assistance and helpful criticism throughout this study the writer is deeply grateful.

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CINCINNATI, OHIO.

Ferns of the Dune Region of Indiana

R. M. Tryon, Jr.

For the purpose of this report the Dune Region may be defined as extending from the eastern boundary of Michigan City on the east to the western boundary of Gary on the west, and from Lake Michigan on the north to Springland Ave. in Michigan City, U.S. 12 and the Grand Calumet River on the south. From the western boundary of Gary to U.S. 12 the Grand Calumet is the southern boundary; east of where U.S. 12 crosses the Grand Calumet the highway is the boundary; in Michigan City Springland Ave. is the southern boundary. North of the southern boundary the younger dunes are untouched except for repeated ground fires over certain areas and for real estate development in Gary, Michigan City and to a lesser extent at Ogden Dunes and Beverly Shores. South of the southern boundary extensive farming and pasturing have destroyed practically all of the fern flora. The area as defined includes all of the typical dunes and all of the typical dune fern flora.

The area is about 30 miles long and from 1 to 3 miles wide. It is located at the southern tip of Lake Michigan, 41° 40′ N latitude and 87° 10′ W longitude. The precipitation averages 33 inches a year with at least 2 inches a month; the average temperature is about 44 F.

One species, *Phegopteris polypodioides* Fee, has been reported in error from the region.[1] The report of this species from Port Chester has never been verified. I have literally combed the region and found nothing but *Phegopteris hexagonoptera* (Michx.) Fee. The habitat of *Phegopteris polypodioides* Fee is not found in the Dune Region. *Phegopteris hexagonoptera* (Michx.) Fee often approaches the form of *Phegopteris polypodioides* Fee and the report was a case of mistaken identity.

Pteretis nodulosa (Michx.) Nieuwl. is a marginal species. I have seen it in the valley of Trail Creek near the town of Trail Creek and it has been reported from the alluvial valley of the Little Calumet River, both localities just outside of our area.

The Indiana Dunes State Park harbors the most ferns, both in species and numbers. All of the species and varieties reported for the Region are found in the State Park. There is a greater range of ecological conditions here than elsewhere and there have been fewer fires and less "improvement." Most of the area is "barren," the ferns being found in a few choice localities: Tamarack Station on the South Shore Railroad, Memorial Park in Michigan City, woods on Beverly Shores just east of the State Park, valley of Silver Creek at Tremont, woods at Port Chester, the Cowles Tamarack Swamp at

1 Pepoon, H. S., An Annotated Flora of the Chicago Region, Chicago Acad. Sci. Bull. 8:143, 1927.

Mineral Springs, pine swamps at Dune Park, and the wooded ravines at Mineral Springs, Ogden Dunes and Miller. The meadows, swales, dry woods and interdunal swamps usually harbor only a few of the commoner species.

I am indebted to Mr. C. A. Weatherby for identifying all doubtful species and varieties, and to Mr. Chas. C. Deam for his valuable aid and suggestions.

Specimens of all species and varieties have been deposited in the Herbarium of the Field Museum.

1. *Polypodium virginianum* L.—Very rare. Has been reported from Miller and Dune Park but it may have died out at those stations. Three plants in the State Park are able to produce only unusually small sterile fronds and bid fair to soon become extinct. Evidently the conditions of growth are far from ideal.

2. *Phegopteris hexagonoptera* (Michx.) Fee—Grows in colonies in damp shady woods. Rare to infrequent, especially outside the State Park. At the east end of Trail 2, in the State Park, it reaches its best development in the region.

3. *Adiantum pedatum* L.—On the north side of dunes where there is plenty of shade and rich loam. Common on a few hillsides but is usually more scattered. May also be found infrequently in damp shady woods.

4. *Pteridium latiusculum* (Desv.) Hieron.—One of our most widely spread species. The Bracken is likely to be found in any of the drier localities and often is found in rather damp situations. It can thrive in almost pure sand and the sunniest of situations. In the more favorable localities it is often over five feet tall.

5. *Woodwardia virginica* (L.) J. E. Smith—Very common in the interdunal swamps between Dune Park and Mineral Springs. Also found in the State Park and Beverly Shores. Usually grows in dense stands. Rarely, the pinnules are pinnatifid.

6. *Asplenium platyneuron* (L.) Oakes—Common locally about Mount Tom. Several plants on the bluffs of Fort Creek. Also found in dunes north of Long Lake, dunes just east of Ogden Dunes and the west bluff of Silver Creek. Its favorite habitat is near the summit of northern mossy hillsides.

7. *Athyrium angustum* (Willd.) Presl.—Grows best in damp shady woods but can tolerate quite a bit of sun. Prefers more water than *A. asplenioides*. Infrequent to common.

var. *rubellum* (Gilbert) Butters—The red-stemmed variety, though this character alone does not identify it; is usually rare but is frequent in a woods north of Furnessville.

var. *elatius* (Link) Butters—A sun form with upturned pinnae. Rare. To identify these and other varieties see Butters, *Taxonomic and Geographic Studies in North American Ferns*, Rhodora 19:169, 1917.

8. *Athyrium asplenioides* (Michx.) Desv.—Grows best in drier situations than *A. angustum*. Sometimes it grows on the northern slopes of hillsides. Infrequent to common.

9. *Athyrium acrostichoides* (Sw.) Diels.—Found in wet shady places with Swamp Saxifrage and Stinging Nettle. A local fern, reaching its maximum development along Trail 2 in the State Park.

10. *Polystichum acrostichoides* (Michx.) Schott.—Found on moist shady hillsides. Rare to infrequent, except in the State Park where it is often common. Also found in damp shady lowlands, especially at the east end of Trail 2 in the State Park, where it reaches its best development in the Dune Region.

f. *incisum* Underw.—Rare. Associated with the type.

f. *crispum* Clute—Rare. Associated with the type.

11. *Thelypteris palustris* var. *pubescens* (Lawson) Fernald—Frequent in damp meadows, swales, and wet shady woods. Distributed throughout, often very common. Rarely fertile in the shade. Sometimes assumes a leaning habit.

12. *Thelypteris noveboracensis* (L.) A. Gray—Very common locally in dry or damp shady woods at Tremont, Port Chester, and Tamarack Station. Elsewhere rare to infrequent in its habitat.

13. *Thelypteris marginalis* (L.) Nieuwl.—Common on a bluff of Trail Creek in Memorial Park, Michigan City. Here it grows on a typical northern dune slope. This fern has been reported from the dunes west of Michigan City but there is no verifying specimen and it should be excluded from the flora of Lake and Porter Counties until there is an authentic report.

14. *Thelypteris cristata* (L.) Nieuwl.—Usually rare or infrequent but it is common in a few choice localities. Grows best in wet shady woods.

var. *clintoniana* (D. C. Eaton) Weatherby—A few plants of this interesting variety are growing with the type in the State Park.

15. *Thelypteris spinulosa* (Muell.) Nieuwl.—Infrequent to frequent in damp or wet shady woods. Found rarely on northern dune slopes in the State Park and east of Ogden Dunes. In wet places it is usually found on a log, tree base, or hummock.

var. *intermedia* (Muell.) Nieuwl.—The variety is sometimes confused with the type. Rare to infrequent, never as abundant as the species. Found with the type in damp shady woods and rarely on a dune slope.

16. *Thelypteris cristata* (L.) Nieuwl. *Thelypteris spinulosa* (Muell.) Nieuwl.—Found rarely wherever the parents are common. Only a few plants in a locality. North of Furnessville, in the State Park, and at Beverly Shores. The fronds are often abortive.

17. *Thelypteris cristata* var. *clintoniana* (D. C. Eaton) Weatherby *Thelypteris spinuosa* var. *intermedia* (Muell.) Nieuwl.—Two plants of this hybrid are growing in the State Park.

18. *Cystopteris fragilis* (L.) Bernh.—A local species, easily overlooked. Grows in shady woods, on earth if it is fairly dry but on tree roots if it is wet. Frequent locally at the southeast corner of the State Park. Also found in the southwest corner of Beverly Shores, north of U.S. 12.

19. *Onoclea sensibilis* L.—The Sensitive Fern, our commonest species, can thrive under a great variety of conditions, demanding only a fair amount of water. It is more fertile in the sun than in the shade. Often forming dense colonies to the exclusion of other plants.

f.*obtusilobata* Torr.—Infrequent along the South Shore Railroad right-of-way, which is mowed once or twice a year. One year I found this form in a ditch, the plant being submerged in the early summer. Likely to be found whenever the early sterile fronds are destroyed.

20. *Osmunda cinnamomea* L.—Grows in dense stands where the dune slope meets the swamp. Prefers damp shady woods but can grow well in the sun. If in the full sun the pinnae turn up and become crowded. Generally common to frequent.

f. *frondosa* (Torrey & Gray) Britton—With the type, rare. The occurrence varies with the year. The spores of this form become mature after the fertile fronds of the type have withered.

f. *incisa* (Huntington) Gilbert—Rare. Usually not a constant form but one colony produces fronds of this variety every year. Often occurs if the young fronds of a plant are mutilated. Sometimes this form intergrades with the former and such fronds might well be called f. *incisa-frondosa*.

f. *auriculata* (Hopkins) Kittredge—Rare. Often found with f. *incisa* and sometimes intergrades with it. Such forms might well be called f. *incisa-auriculata*.

21. *Osmunda regalis* var. *spectabilis* (Willd.) Gray—Distributed throughout in damp meadows, wet woods, and along the borders of swales. Prefers more water than *O. cinnamomea* and is more common. A form analogous to *O. cinnamomea* f. *frondosa* is sometimes found.

22. *Osmunda claytoniana* L.—Locally common or infrequent in small isolated colonies. Fertile fronds are found only where it is damp but it can thrive in fairly dry localities.

23. *Ophioglossum vulgatum* L.—Very rare. Has been reported from Gary, Miller and Mineral Springs but the two former stations have probably been usurped by factories and real estate activity. A few plants are growing in the State Park. It is also found at Liverpool just to the south of our area. A small inconspicuous plant, probably often overlooked.

24. *Botrychium dissectum* Spreng.—Occurs rarely in damp shady woods

and thickets. Locally frequent at Tamarack Station; also found north of Furnessville, in the State Park, and in the valley of Silver Creek.

f. *obliquum* (Muhl.) Fernald—Grows with the type but is always more common. Usually rare in its habitat but frequent to common in a few choice places. Tamarack Station, Beverly Shores, north of Furnessville, Dunes State Park, Tremont, and westward.

f. *oneidense* (Gilbert) Clute—Very rare. I have a few plants from the State Park and the woods at the southwest corner of Beverly Shores, north of U.S. 12. Found in damp shady woods along Trail 2 in the State Park and on the higher ground in swampy woods at Beverly Shores.

f. *elongatum* (Gilbert & Haberer) Weatherby—Rare. Found with f. *obliquum*.

To identify these forms see Weatherby, *A List of Varieties and Forms of the Ferns of Eastern North America*, Amer. Fern J. 25:50, 1935.

25. *Botrychium ternatum* var. *intermedium* D. C. Eaton—A very rare plant usually growing in half-sunny sand. Miller and Dunes State Park. There are eight plants at three stations in the State Park.

26. *Botrychium virginianum* (L.) Sw.—Scattered infrequently throughout in damp or dry, shady situations. Common in a few choice localities. Plants with half-sterile spikes are sometimes found.

CHESTERTON, INDIANA.

Bibliography of the Botany of Arizona

Joseph Ewan

An introductory bibliography for the Arizona flora but from which "many titles have been omitted purposely" was given by Prof. J. W. Harshberger in his "Phytogeographical Survey of North America" (Engler and Drude, Die Vegetation der Erde XIII) published in 1911. The Arizona items must be culled from "Section V. Southwestern Arid States and Great Basin" (pp. 75-78) of his larger division "Special Works on the Territories." In the intervening quarter of a century since its publication there have appeared in a wide assortment of books and periodicals, botanical and non-botanical, scientific and popular, numerous articles of varying value on the flora of the region. To include these more recent contributions and to exhume the older less familiar references is the object of the present bibliography covering an eighty-six year period (1848-1934).

Here the emphasis has been at all times taxonomic and floristic but with such entries added from zoological fields as might prove of supplementary botanical value. Books or papers on the flora of adjacent states or of a monographic nature, when these give only scattered references to Arizona species, are excluded with exception of ferns. Likewise articles treating of a single species except when peculiarly Arizonan, accounts essentially agricultural or economic, or papers of an ecological nature based on a few species not signally Arizonan though emanating from that state, are not included. On the other hand papers including assorted new species or miscellaneous notes which might from their titles be unsuspected of yielding Arizona references have, so far as discovered, been included. Annotations are freely given, particularly for those titles which do not convey an adequate idea of their scope or contents, as well as occasional comment of the compiler relative to the prospect for the user. Certain unpublished theses of the University of Arizona are included. Under the opportunities of inter-library loan these papers, often of pertinent merit, are available to a wider group of readers than commonly realized. Newspaper articles of C. C. Parry, the conciliatory pilgrim of botany across emergent West-America, are of exceeding interest and value in certain problems of fixing the origin of his critical collections. It is unfortunate that these are not widely available. Papers on cryptogamic botany have not been religiously searched out, but all that have come to my notice are included. A few titles have not been seen; these are indicated in all cases with the source furnishing the entry. Two indices conclude the bibliography: a geographic index and one to authors. The available longer papers for any part of the state and the year or years of publication for an author may be quickly ascertained by the use of these guides. For these suggestions I am indebted to the admirable ornithological bibliographies of Prof. Joseph Grinnell. P. C. Standley has prepared an annotated bibliography to the botany of New Mexico (Contr. U. S. Nat. Herb. 13:229-246, with

map in color, 1910). This is constructed along somewhat different lines in that references are included for species mentioned in monographs or within papers of wider scope.

"Bibliography is never finished," says Elliott Coues, "and always more or less defective, even on ground long gone over. It is earnestly hoped that the errors or omissions of this piece of work may be brought by those interested to the compiler's notice. In fact, one object in printing the present batch of titles is to invite criticism, to the end that the final bibliography may be bettered." In all of these points the present compiler is in complete accord with Coues, and with him "feels the weight of Steven's satire: 'if you are troubled with a pride of accuracy, and would have it completely taken out of you, print a catalogue'" (U. S. Geol. Surv. of Terr. Misc. Publ. 11:569, 1878).

Arizona place names are not at all times of easy orientation on maps at hand, particularly in matter of towns of a half-century ago. In such geographical quests I have found Arizonology (Knowledge of Arizona) by Elwood Lloyd IV, a handbook published by *Coconino Sun*, Flagstaff, 1933, to be of nearly unfailing usefulness. A more recent work on the same subject is W. C. Barnes' Arizona Place Names, published as Univ. Arizona Gen. Bull. 2, 1935, available from the Librarian at the University. This reasonably exhaustive gazetteer is the fruition of thirty years' gleanings.

This bibliography was begun in 1931 as a reference aid to the author's study of the admirably prepared plant collections of Mrs. Susan W. Hutchinson of Los Angeles, coming chiefly from the Chiricahua, Huachuca, Baboquivari and White mountains. The field of the work was extended as its wider service suggested itself. The library facilities about Los Angeles were first employed but the final check of pagination and the addition of many entries not previously available have been completed at the Library of the University of California at Berkeley. To the staff of this Library, and particularly to its Biology Library personnel, do I express my sincere thanks.

Bibliographies may at the same time be histories. It is for this reason that the items have been arranged chronologically. Botanical exploration in Arizona, as with other areas newly opened to science, has given rise to its literature. Adolph Wislizenus wrote in 1848, "towards the west of New Mexico an immense country is spread out between the Rio Colorado and the Gila, inhabited only by wild Indian tribes. This whole wide country is sometimes allotted in the Mexican maps to Sonora, sometimes to Upper California, but generally to New Mexico, while the larger waste desert northwest of the Colorado is generally attributed to California" (Mem. Tour to Northern Mexico . . . in 1846 and 1847, p. 22). Wislizenus did not explore this "immense country" but botanized in what now comprises the state of New Mexico. Thirty-four years ago J. B. S. Norton when surveying briefly the extent of botanical exploration over the United States remarked that "portions of Arizona and Colorado have been well worked and others are almost unknown" (Trans. St. Louis Acad. Sci. 12:36, 1902). Similarly Anstruther Davidson wrote in 1904, " the greater part [of Arizona] is practically unknown to the naturalist and many years must elapse before the work of exploration is even

superficially performed" (Bull. S. Calif. Acad. Sci. 3:110). Today the Arizona flora is of course better known, largely through the explorations of J. C. Blumer, F. R. Fosberg, J. W. Gillespie, M. E. Jones, Dr. Forrest Shreve, Prof. J. J. Thornber, Ivar Tidestrom and notably by the recent close collecting of Dr. T. H. Kearney and associates at the Sacaton station of the Bureau of Plant Industry, U. S. Department of Agriculture. Toward a further knowledge of the Arizona flora, characterized by Davidson as "probably the most interesting and varied flora of any state in the Union," the present bibliography may open otherwise unnoticed avenues of investigation.

1848. TORREY, J. [Botanical Appendix] *in* W. H. EMORY, Mil. Recon. 135-156. pl. 1-12. 30th Congress, Senate Executive [Document] No. 7.

Notes and many original descriptions (as *Cereus giganteus)* for plants collected on "hills bordering the Gila." *Cf.* Barnhart, Bull. Torr. Club 22:394-395. 1895 and Coville, *ibid.* 23:90. 1896 regarding variations in composition and pagination according to edition. The latest note relative to this matter is offered by Britton and Rose: "Emory's Report. . . was printed at least twice the same year and about the same date, once as a Senate Document (Executive Document No. 7) and once as a House Document (Executive Document No. 41). . . . there has been considerable speculation and much difference of opinion as to which edition was published first, but we have recently come into possession of Emory's personal copy of the Senate Document No. 7 marked 'with manuscript corrections by the author'. From this copy the type of the other edition was set up." (Carn. Inst. Wash. Publ. 248(2):164, 1920).

1853. TORREY, J. Catalogue of plants collected on an expedition down the Zuñi and Colorado rivers by Capt. L. Sitgreaves. Wash. *In* report of the expedition, 153-178. 21 pl.

1855. GRAY, A. Plantae Novae Thurberianae. Mem. Am. Acad. 5:297-328.

Holacantha, Petalonyx and *Olneya* described as new genera from George Thurber's collections in Gila River country, though the bulk of his collections made in Sonora, with a few from California and New Mexico. His route from Colorado River near its junction with Gila was via Pimo Villages, Salinas River, Tucson, Santa Cruz, Janos, Corralitos to El Paso.

1857. BIGELOW, J. M. General description of the botanical character of the country [near the 35th parallel, explored by A. W. Whipple, 1853-1854]. U. S. War Dept. Rep. Explor. & Surv. for a R. R. route from Mississippi R. to Pac. Ocean 4:1-16. 1 pl.

Sections 6-8: Valley of Zuñi, San Francisco Valley and Santa Maria Valley are of pertinent interest. Date ascertained as noted in following entry.

1857. TORREY, J. Description of general botanical collections [made by J. M. Bigelow between Rio Grande and Bill Williams Fork of Colorado "chiefly between the parallels of 35° and 36°," explored by A. W. Whipple, 1853-1854]. *Ibid.* 4:59-167. 25 pls.

Chiefly Californian notes however. Though this volume most usually cited "1856," as on title page, it could not have appeared before 1857 as Torrey's "Introduction" dated "Jan. 12, 1857."

1857. TORREY, J. Descriptions of plants collected along the route [explored by R. S. Williamson in California], by W. P. Blake, and at the mouth of the Gila. *Ibid.* 5:359-370. 10 pls.

Date determined as in preceding entry. Torrey's preface dated "May 1, 1857" though date commonly given as "1856."

1857. TORREY, J. List and description of plants collected [by T. Antisell (acc. Standley, Contr. U. S. Nat. Herb. 13:151) along route near thirty-second parallel, between Rio Grande and Pimas Villages, explored by J. G. Parke in 1854-1855]. *Ibid.* 7[3]:1-28. 8 pls.

"Chiricahui Mountains" [sic], then a part of "New Mexico," are frequently mentioned. "Synoptical Table," prepared by Antisell, for Gila River and eastward, p. 25.

1859. TORREY, J. AND PARRY, C. C. Botany of the Mexican Boundary. *In* W. H. EMORY, Report on the U. S. and Mex. Boundary Survey. 2[1]:1-270. 61 pls.

Parry's "Introductory chapter on geographical distribution and botanical features" appears on pp. 9-26. Torrey's report, 27-270. Engelmann's monographic work on *Cactaceae* carries separate pagination.

1861. GRAY, A., TORREY, J., THURBER, G., AND ENGELMANN, G. Catalogue of plants collected upon the expedition upon the Colorado River of the West. Ives Expedition of 1857-1858. Pt. 4:5-30.

1866. COUES, E. List of the birds of Fort Whipple, Arizona: . . . etc. Proc. Acad. Nat. Sci. Phila. 18:39-100.

Pages 39-42 carry valuable geographic notes on region and though primarily a paper on the "Ornis of Arizona" of supplementary botanical value for a poorly known time.

1866. COUES, E. From Arizona to the Pacific. Ibis ser. 2, 2:259-275.

Ornithological notes from Fort Whipple to Fort Mojave (and on to San Pedro, Calif., where he spent a day "most delightfully sailing about with Dr. Cooper") but notable for description of the country traversed.

1868. PARRY, C. C. From Arizona. An interesting account of the territory. Davenport [Iowa] Gazette. 6 Jan. 1868.

Newspaper article, not seen, which should prove of value. (from Mrs. Parry, Proc. Davenp. Acad. Sci. 6:51. 1893).

1868. PARRY, C. C. Great Colorado of the West. Its navigable waters and deep cañons. Davenp. [Iowa] Gazette. 11 Feb. 1868.

Newspaper article, not seen, from reference above.

1869. COOPER, J. G. Naturalist in California. Am. Nat. 3:470-481.

Primarily ornithological but inasmuch as Cooper, "so well known as an indefatigable and accurate naturalist," botanized at Fort Mojave, on Colorado River, Arizona (*cf.* Brewer, Bot. Calif. 2:558, 1880), the article is of value towards a knowledge of his botanical movements in the region.

1870. PARRY, C. C. Botany of the region along the route of the Kansas Pacific Railway, through Kansas, Colorado, New Mexico, Arizona,

and California. Appendix A. pp. 521-538 *in* BELL, W. A. New Tracks in North America . . . etc. ed. 2. 565 pp. Chapman & Hall, London. [Also extract, without appended list, reprinted from ed. 1 *in* PALMER, WILLIAM J., Rep. Kansas Pac. Railway Survey in 1867-1868. pp. 213-220, 1869.]

General remarks on the character of the flora, of forest trees and concluding with an important "List of plants collected or observed on the survey of the Kansas Pacific Railway, in 1867 and 1868. (The numbers refer to the author's collection in the Botanical Department of the British Museum)." This systematic list comprises over ten closely filled pages; citations of localities given in greater or less detail in all cases, with appended numbers for about half the species listed. Also some scattered references to Dr. Parry in body of text.

1870. PARRY, C. C. North America desert flora between 32° and 42° north latitude. Jour. Bot. 8:343-347.

"To exhibit the main features of desert vegetation" but merely an unannotated list of 188 species without indication of range or locality. Abstract *in* Rep. Brit. Asso. Adv. Sci. 1870:122, 1871 which includes salient points and is of nearly equivalent value.

1873. WATSON, S. New plants of northern Arizona and the region adjacent. Am. Nat. 7:299-303.

Advance descriptions of plants of Wheeler Expedition of 1871-1872.

1874. WHEELER, G. M. Catalogue of plants collected in the years 1871, 1872, and 1873 with descriptions of new species. U. S. Geog. [& Geol. Explor. &] Surv. west of the 100th merid. Wash. 62 pp. 23½ cm.

"Botanical Report" by Sereno Watson, p. 5-19, of Rothrock's collections crediting several species merely to "Arizona." Remainder of the paper comprises Rothrock's "Preliminary Report on the Botany of Central Colorado," completing the pamphlet as issued (*cf.* Bull. Torr. Club 12:36).

1875. LOEW, O. Geographical distribution of plants [in Arizona and New Mexico], list of plants of medical and technical use, chemical constituents of soapweed [Yucca baccata], mescal ["Agave decipiens"] and "investigation of Ephedra antisyphilitica." *In* WHEELER, G. M. Report U. S. Geog. Surv. west of 100th merid. 3(6):603-612.

Historical rather than descriptive in value.

1877. HOFFMAN, W. J. Distribution of vegetation in portions of Nevada and Arizona. Am. Nat. 11:336:343.

Interesting account but wanders from subject towards end. Chiefly on Gila Desert and vicinity of Bill Williams Fork with references to points east in less detail.

1879. EATON, D. C. Ferns of the Southwest. *In* WHEELER, G. M. Report U. S. Geog. Surv. west of 100th merid. 6:299-340.

Eaton's paper, though included here against usual practice, was of such epochal value for the state and served so effectively as a sound foundation for later pteridological work in Arizona, that it is here entered.

1879. ROTHROCK, J. T. Reports upon the botanical collections made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the years 1871-1875. *In* WHEELER, G. M. Rep. U. S. Geog. Surv. west of 100th merid. 6:17-37, 53-297. "1878."

First appeared in May 1879 contrary to title page (*cf.* Proc. U. S. Nat. Mus. 23:622. 1901). Important Arizona notes and references throughout "catalogue" and also in section "New Mexico and Arizona District."

1880. STILLMAN, J. M. Gum lac from Arizona. Am. Chem. Jour. 2:34-38.

From "Larrea mexicana" and *Acacia Greggii*.

1881. GREENE, E. L. New plants of New Mexico and Arizona. Bot. Gaz. 6:183-185, 217-219.

Bigelovia rupestris and *juncea*, *Euphorbia versicolor*, and *Penstemon vinifolius* described from Arizona.

1881. JAMES, J. F. Botanical notes from Tucson. Am. Nat. 15:978-987.

Of variable merit but for its period a highly informative article. "Whole of the flora of Southern California, Arizona and New Mexico belongs to the Mexican region" must obviously be modified.

1882. GRAY, A. Novitiae Arizonicae, etc.; characters of the new plants of certain recent collections, mainly in Arizona and adjacent districts, etc. Proc. Am. Acad. 17:199-230. Issued 26 June 1882.

Many new species described from Pringle and Lemmon collections.

1882. JONES, M. E. Ferns of the West. 31 pp. Palmerston & Lincoln, Salt Lake City.

Because of abundant Arizona references and full descriptions given this comprehensive fern flora for western North America is included.

1882. LEMMON, J. G. Ferns of the Pacific Coast, including Arizona. "First edition." 15 pp. Bacon, San Francisco.

This pamphlet, like the last, is here included against general rule because of high value for Arizona service in a little-studied field.

1882. PARRY, C. C. Desert Ironwood. Explorations in the Mojave and Arizona regions. San Francisco [Calif. Evening] Bulletin 12 Jan. 1882.

Newspaper article, written from Colton, Calif. where, Mrs. S. B. Parish tells me, he knew the only banker in town. He had detrained from the Southern Pacific upon which he rode gratis by courtesy of Leland Stanford. Notes on the discovery of *Olneya* "at foot of Signal Mountain" (Parry having been a member of the Mexican Boundary Survey) and also mentions its occurrence in "lower Valley of the Gila." Much additional matter on possible uses of "a leguminous tree of future economic value."

1882. RUSBY, H. H. Notes on the trees of the Southwest. Bull. Torr. Club 9:53-55, 78-80, 106.

In San Francisco, Burro and Bear mountains of Arizona.

1882. SCRIBNER, F. L. List of grasses collected by Mr. C. G. Pringle in Arizona and California during the summer of 1881. Bull Torr. Club 9:74-77, 86-89, 103-105, 145-149. 10:29-32.

1883. HAMILTON, P. Fauna and Flora [of Arizona]. *In* Resources of Arizona. ed. 2, pp. 33-42. Published "under auth. legisl." of Arizona, at San Francisco, Calif.

Notes on "Cereus gigantus" [*sic*], ocotilla, mescal, amole, and other botanical "resources" of the state—obviously of minimum value.

1883. LEMMON, J. G. Discovery of potato in Arizona. Overland Mo. ser. 2, 1:369-382, 513-519. [Theatrical portions of article reprinted *in* George Wharton James' Heroes of California pp. 326-332. 1910.]

Full account, with historical background (a detailed compilation), of the discovery of a "form of original Solanum tuberosum of South America" in Huachuca Mts. in summer of 1882. Additional notes of value on general botanical peregrinations of the Lemmons, contributing to our sketchy knowledge of their itineraries.

1884. HAVARD, V. Mezquit. Am. Nat. 18:451-459.

Spelling is "Americanized" Mexican form for "mesquite." Includes such topics as "name, habitat, properties and growth, climate and soil, uses," etc. etc.

1885. GRAY. A. New genera of Arizona, California, and their Mexican borders, and two additional species of Asclepiadaceae. Proc. Am. Acad. 20:290-296. Issued 26 Jan. 1885.

Characterization of genus *Rothrockia* Gray, *Lachnostoma arizonicum* Gray and *Acerates bifida* Rusby ex Gray.

1885. GRAY, A. How to reach the Grand Cañon. Sci. 5:516-517.

Note of Dr. Gray's "stop-over" at the canyon, made by means of "a three-seated wagon, upon the buckboard principle, drawn by four experienced horses," with mention of the historic personages who went before him.

1885. NELSON, E. W. Explorations in southern Arizona. Smiths. Inst. Rep. Wash. 1884:20-24.

Of non-botanical intent but of botanical interest for its topographic notes made by a careful biologist.

1885. PRINGLE, C. G. Pringle's distribution of 1884. Flora of Arizona and Sonora. Oquawka, Ill. [by H. N. Patterson] 8vo.

According to Bibliog. Contr. Lloyd Lib. 1:398, 1913 of three pages and dated "1884" but acc. Kew Bull. Misc. Info. add. ser. 3:501, 1899 published in 1885. Not seen, apparently a check-list of his exsiccatae.

1886. MATTHEWS, W. Navajo names for plants. Am. Nat. 20:767-777.

Carefully prepared systematic list arranged by families.

1887. MADINIER, P. Note sur la distribution géographique de quelques plantes économiques de l'Arizona, la Californie méridionale et le Nouveau Mexique et sur la climatologie de la zone désertique qu'elles habitent. 23 pp. Alger.

Not seen. From Bradley Bibliography 1:325, 1911.

1888. LEMMON, J. G. Grand Cañon of the Colorado. Overland Mo. 12:244-256 of ser. 2 (pagination of this periodical eccentric).

Full, often spirited, description of the region, giving useful clues towards Lemmon's itinerary apart from its interest as a document of the period.

1888. TRACY, S. M. Report of an investigation of grasses of arid districts of Texas, New Mexico, Arizona, Nevada, and Utah in 1887. U. S. Dept. Agric. Bot. Div. Bull. 6:1-29.

Grasses of the vicinity of Winslow, Flagstaff, Peach Springs and Grand Canyon.

1888. VASEY, G. Characteristic vegetation of the North American desert. Bot. Gaz. 13:258-265.

General discussion, with much quoted matter from Watson, Rothrock and others, and little new material. "Galea" should read "Dalea" (i. e. *Parosela*), p. 262, l. 27.

1889. BRITTON, N. L. List of plants collected at Fort Verde and vicinity and in the Mogollon and San Francisco mountains, Arizona, 1884-1888, by Dr. E. A. Mearns, U. S. A. Trans. N. Y. Acad. Sci. 8:61-76.

1889. RUSBY, H. H. General floral features of the San Francisco and Mogollon mountains of Arizona and New Mexico, and their adjacent regions. Trans. N. Y. Acad. Sci. 8:76-81.

1890. MERRIAM, C. H. Results of a biological survey of the San Francisco Mountain Region and desert of the Little Colorado in Arizona. No. Am. Fauna 3:1-34.

Important notes on the "origin of the fauna and flora," vegetational zonation and component species of these associations in a report mainly zoological.

1891. JONES, M. E. New plants from Arizona, Utah and Nevada. Zoe 2:12-17.

1891. ROSE, J. N. List of plants collected by Dr. Edward Palmer in western Mexico and Arizona in 1890. Contr. U. S. Nat. Herb. 1:91-127.

The list of Arizona collections appears on pp. 117-127.

1892. COVILLE, F. V. Descriptions of new plants from southern California, Nevada, Utah, and Arizona. Proc. Biol. Soc. Wash. 7:65-80.

Stylocline arizonica described from Verde Mesa.

1892. DEWEY, L. H. Characteristic vegetation of the desert region from western Texas to central Arizona. U. S. Dept. Agric. Rep. of Secr. 1891:351-355, 8 pls.

Eleven arboreous species briefly described from "travelling on Southern Pacific Railroad, and stopping at . . . Tucson and Maricopa" with Phoenix as destination.

1892. TOUMEY, J. W. Bit of the flora of central Arizona. Bot. Gaz. 17:162-164.

To Camp Verde via "old Black Cañon stage route between Phoenix and Prescott," with stop-over at Big Bug Mines.

1893. MERRIAM, C. H. Notes on distribution of trees and shrubs in the deserts and desert ranges of southern California, southern Nevada, northwesern Arizona, and southwestern Utah. No. Am. Fauna 7:285-343.

Systematic list, after determinations of F. V. Coville, of species with detailed notes on then-known distribution. Beaverdam and Virgin mountains of Arizona sparingly mentioned.

1893. MERRIAM, C. H. Notes on the geographic and vertical distribution of cactuses, yuccas, and agave, in the deserts and desert ranges of southern California, southern Nevada, northwestern Arizona, and southwestern Utah. No. Am. Fauna 7:345-359.

Systematic list in identical manner of the preceding with same Arizona localities mentioned.

1893. TOWNSEND, C. H. T. Wagon-trip to the Grand Cañon of the Colorado River. Appalachia 7:48-63.

Detailed itinerary of journey from Las Cruces, N. M., with scattered references to the vegetation. E. O. Wooton was botanist on the trip, joined at Flagstaff by J. W. Toumey.

1893. TOWNSEND, C. H. T. An ascent of San Francisco Mountain (Arizona) and the homeward route. Appalachia 7:149-157.

Supplementary chapter to last account, with same botanical personnel (i. e. "heavy-weight" Toumey and "featherweight" Wooton) and some botanical allusions.

1894. BRITTON, N. L. AND KEARNEY, T. H., JR. Enumeration of the plants collected by Dr. Timothy E. Wilcox, U. S. A. and others in southeastern Arizona during years of 1892-1894. Trans. N. Y. Acad. Sci. 14:21-44.

Mostly about Ft. Huachuca and Ft. Apache with a "few near San Carlos and in Tanners Cañon."

1895. TOUMEY, J. W. Notes on the tree flora of the Chiricahua Mountains. Garden and Forest 8:12-13, 22-23.

1895. TOUMEY, J. W. Vegetal dissemination in the Genus Opuntia. Bot. Gaz. 20:356-361.

Concerns chiefly *Opuntia basilaris, chlorotica, fulgida, phaecantha,* and *Bigelovii.*

1895. TOUMEY, J. W. New or little-known plants. Garden and Forest 8:154, 184 (unsigned), 324-326.

"Echinocactus wislizenii and some related species"; "An Arizona Agave" (*A. huahucensis* Baker); "Opuntia fulgida" are the titles of the illustrated notelets.

1895. TOWNSEND, C. H. T. On the biogeography of Mexico, Texas, New Mexico, and Arizona. Trans. Texas Acad. Sci. 1:71-96.

"With special reference to the limits of the life areas and a provisional

synopsis of the biogeographic divisions of America." With "provisional tabular synopsis of the recognized life divisions of America," including South America.

1896. FERNOW, B. E. Arizona forests. Forest Leaves 5:180.

Not seen; acc. Rehder, Bradley Bibliog. 1:320. 1911.

1897. FERNOW, B. E. Forests and deserts of Arizona. Nat. Geog. Mag. 8:203-226. illust.

"Address delivered before National Geographic Society." Quasi-Chautauquan in content, non-botanical.

1897. HOUGH, W. Hopi in relation to their plant environment. Am. Anthropol. 10:33-44.

Ethnobotany of Hopis of northeastern Arizona. Uses and Indian names of the plants and plant parts, arranged under such headings as "food," "arts," "medicine," etc., the determinations by J. N. Rose.

1897. TOUMEY, J. W. Notes on the pine forests of southern and central Arizona. Garden and Forest 10:152-153.

Distribution of pines on the "mountain ranges south of Colorado Plateau."

1897. TOUMEY, J. W. Giant Cactus. Pop. Sci. 51:641-644. illust.

Brief account of its life history.

1897. TOWNSEND, C. H. T. On the biogeography of Mexico and the southwestern United States. Trans. Texas Acad. Sci. 2':33-86.

Mainly extra-Arizonan in subject matter but with many incidental comparisons.

1898. BRAY, W. L. On the relation of the flora of the Lower Sonoran Zone in North America to the flora of the arid zones of Chile and Argentine. Bot. Gaz. 26:121-147.

Valuable documented discussion by families of the origin and affinities of xerophytic and halophytic elements on the two continents.

1898. BURTT DAVY, J. Burmuda grass in Arizona. Erythea 6:24-25.

1898. HOUGH, W. Environmental interrelations in Arizona. Am. Anthropol. 11:133-155.

Ethnobotany of the Hopi (or Moki) with introductory remarks on the broad biologic interaction of forces in arid habitats. Detailed notes on Indian uses of native plants in food, domestic life, medicine, etc., concluding with a "systematic list of species."

1898. PURPUS, C. A. Bericht des Herrn C. A. Purpus über seine Tour in das Wüstengebiet des südlichen und mittleren Nevada, nördlichen Arizona und westlichen Utah. Deutsch. Dendr. Ges. Mitteil. 7:66-78. Also reprinted, as a one-volume "second edition," 404-416. 1909.

Account of botanical "tour" which only barely penetrated northern borders of Arizona en route to Beaverdam Mts., Utah, from Virgin Mts. of Nevada.

1899. PURPUS, C. A. Eine Succulententour in das Wüstengebeit des süd-

lichen Nevada, des nordwestlichen Arizona und des südwestlichen Utah, 1896. Monatsschr. für Kakteenkunde 9:49-52, 65-68, 1 fig.

Itinerary only touches northern Arizona border and hence almost negligible for that state, being an interestingly written account of the *Cactaceae* of region to north and west of the Arizona borders.

1899. TOUMEY, J. W. Natural reforestation in Southwest. Forester 5: 145-147, 1 pl.

General non-botanical comment on Arizona conditions, with mention of grazing in central Arizona and effect on Salt River Valley agriculture.

1900. COCKERELL, T. D. A. Notes on some southwestern plants. Bull. Torr. Club 27:87-89.

Kallstroemia grandiflora var. *arizonica* as new and notes on *Holacantha* and *Prosopis velutina*.

1900. COCKERELL, T. D. A. Lower and Middle Sonoran zones in Arizona and New Mexico. Am. Nat. 34:285-293.

A comparison between Mesilla and Salt River valleys with correlations between plants and insects—title ambitious for scope of the paper.

1900. HOUGH, M. Z. Plant names of the southwestern United States. Pl. World 3:137-139.

List of Mexican names for commoner species. Interesting adjunct to Matthews' paper of 1886 but less detailed and scholarly.

1901. GRIFFITHS, D. Range improvement in Arizona. U. S. Dept. Agric. Bur. Pl. Indust. Bull. 4:1-31, 6 pls.

Analysis of grasses, with here detailed reference to species, and browse plants (including four *Opuntia* species) chiefly from southern Arizona.

1902. HOLSINGER, S. J. Mesquite: a desert study. Forestry and Irrig. 8:447-453, illust.

Consideration of "habits and uses" of *Prosopis juliflora* and *P. velutina*, with descriptions of each.

1902. KELLOGG, R. S. Forest conditions in southern Arizona. Forestry and Irrig. 8:501-505, illust.

Gross analysis of forest cover of the Huachuca, Graham, Chiricahua and Santa Catalina ranges.

1902. MACDOUGAL, D. T. Report [to Director N. L. Britton] of Dr. D T. MacDougal, First Assistant, on an expedition to Arizona and Sonora. Jour. N. Y. Bot. Gard. 3:89-99, 8 figs.

Report of field work with brief notes on region traversed.

1902. TOUMEY, J. W. Study in plant adaptation. Pop. Sci. 61:483-491, 6 figs.

Treats of *Opuntia fulgida*.

1902. TULLSEN, H. Is the giant cactus doomed? Pl. World 5:53.

Negative reply to a journalistic scare.

1903. COVILLE, F. V. AND MACDOUGAL, D. T. Desert Botanical Laboratory of the Carnegie Institution. Carn. Inst. Wash. Publ. 6:1-58. 29 pls., 4 figs.

For a detailed synopsis of the scope of this and other papers in this important series see Classified List of Publications, Carnegie Institution of Washington, 1927, pp. 42-53.

1903. KUNZE, R. E. Desert flora of Phoenix, Arizona. Bull Torr. Club 30:302-307.

1903. MACDOUGAL, D. T. Some aspects of desert vegetation. Pl. World 6:249-257.

Seven environmental aspects discussed against an Arizonan background.

1904. DAVIDSON, A. Flora of Clifton District, Arizona. Bull S. Calif. Acad. Sci. 3:110-111.

"District covered extends from the New Mexico border near Duncan, twenty-five miles south of Clifton, to the Blue River, a tributary of the Frisco [San Francisco River], nearly twenty-five miles north of Clifton and west along Chase Creek for twelve miles."

1904. GRIFFITHS, D. Range investigations in Arizona. U. S. Dept. Agric. Bur. Pl. Indust. Bull. 67:1-62, 10 pls.

Grasses, chenopods, *Trifoliums*, *Erodium*, *Cruciferae*, etc., of chiefly southeastern Arizona, with occasional mention of their distribution over the state.

1904. LEIBERG, J. B. AND OTHERS... Forest conditions in the San Francisco Mountains Forest Reserve, Arizona. U. S. Geol. Surv. Prof. Paper 22:1-95, 7 pls.

Includes notes on "zones or types of arborescent growth" (p. 18) and "species of trees" (21-22).

1904. MACDOUGAL, D. T. Delta and desert vegetation. Bot. Gaz. 38:44-63, 7 figs.

Extralimital but useful for extreme southwestern part of the state, an area for which there is scant literature.

1904. MACDOUGAL, D. T. Botanical explorations in the Southwest. Jour. N. Y. Bot. Gard. 5:89-98, 6 figs.

Second report of field work. See same author for 1902.

1904. PLUMMER, F. G. Forest conditions in the Black Mesa Forest Reserve, Arizona. U. S. Geol. Surv. Prof. Paper 23:1-62, 7 pls.

"List of trees and stand of timber, timber zones, description of trees," pp. 15-17.

1904. SPALDING, V. M. Biological relations of certain desert shrubs. Bot. Gaz. 38:122-138.

Explanatory subtitle: Creosote Bush *(Covillea tridentata)* in its relation to water supply. Arizona references.

1904. SWARTH, H. S. Birds of the Huachuca Mountains, Arizona. Cooper Ornith. Club Pac. Coast Avifauna 4:1-70.

Introduction contains general notes of interest relative to the vegetation.

1904. VRIES, HUGO DE. Das Wüsten-Laboratorium zu Tucson in Arizona. Naturwissenschaftliche Wochenschrift (Neue Folge 3. no. 26) 19:401-403.

Account of establishment and program of the Desert Laboratory at Tucson by a visitor.

1905. DAVIDSON, A. Flora of Clifton District, Arizona, II-IV. Bull. S. Calif. Acad. Sci. 4:18-19, 35-36, 130-131.

Continuation of the series of lists begun in 1904.

1905. INGERSOLL, E. Plant life in the desert. Harpers Mag. 110:577-583.

Regurgitation of geobotanical matter for public consumption. Illustrations "by courtesy of the Carnegie Institution." In short, plant ecology of Arizona for the masses.

1905. RIXON, T. F. Forest conditions in the Gila River Forest Reserve, New Mexico. U. S. Geol. Surv. Prof. Paper 39:1-89. map.

Extralimital in subject matter, but since this region adjoins Greenlee County, Arizona, on the east, the present paper supplements Davidson's papers on Clifton area *(cf.* 1904 *et seq.)*. "Trees and shrubs indigenous to. . . . Reserve" and a brief account of timber zones (pp. 19-20).

1906. BREEN, F. S. Black Mesa Forest Reserve. Forestry and Irrig. 12:149-153, illust.

"Located in the wildest and most broken part of the Territory." Brief analysis of the forest cover of Mogollon Mts. with mention of species.

1906. CANNON, W. A. Two miles up and down in an Arizona desert. Pl. World 9:49-55.

Discussion of "floral belts" according to author's original terminology, applied to the San Francisco Mts. and Grand Canyon, with designation of dominants.

1906. DAVIDSON, A. Flora of Clifton District, Arizona, V. Bull S. Calif. Acad. Sci. 5:67-70.

1906. GREENE, E. L. Genus Ptelea in the western and southwestern United States and Mexico. Contr. U. S. Nat. Herb. 10:49-78.

Fifteen species described as new for Arizona. Interesting as a record of old-time collectors in the state since Greene examined material in several herbaria.

1906. HALL, S. M. Forests of Arizona. Out West 25:472-509, 29 figs.

Popular style but one of the best among its class. Also includes a detailed account of lumbering with species concerned.

1907. DAVIDSON, A. Flora of Clifton District, Arizona, VI. Bull. S. Calif. Acad. Sci. 6:34-36.

1907. LLOYD, F. E. Pima Cañon and Castle Rock in the Santa Catalina Mountains. Pl. World 10:251-259.

Plant associations discussed.

1907. PURPUS, A. AND C. A. Arizona. *In* KARSTEN, G. UND SCHENK, H. Vegetationsbilder 4[T]: pls. 37-42. Gustav Fischer, Jena.

Fine series of photographs taken by C. A. Purpus with accompanying notes on plant associations illustrated and some mention of the influence of climate.

1907. SPALDING, V. M. Spring flowers of the Arizona desert. Pl. World 10:63-64.
Thirty-two species of Tucson area alluded to but not listed.

1907. THORNBER, J. J. Alfilaria in Arizona. Pl. World 10:205-208.
Erodium cicutarium adventive from Southern California with sheep drive of 1870-1871.

1907. VRIES, HUGO DE. Naar Californie II. [collected essays in book form] 2:36-63.
Notes on Arizona travels, particularly from Grand Canyon.

1908. BLUMER, J. C. Flowering season in the mountains of Arizona. Muhlenbergia 4:77-81.
List of important species of Barfoot Park, Chiricahua Mountains, arranged by habitat.

1908. BLUMER, J. C. Distributional features of some southwestern shrubs. Pl. World 11:117-123.
Lippia Wrightii, Quercus reticulata, Parkinsonia Torreyana, Acacia Greggii, Prosopis juliflora, Zizyphus lycioides, and *Celtis pallida* treated in some detail.

1908. BLUMER, J. C. Some observations on Arizona fungi. Pl. World 11:14-17.
"Particularly of Chiricahuas."

1908. BROWN, H. Hashish plant in Arizona and Mexico. Pl. World 11:180-183.
Cannabis indica, otherwise known as "marijuana," under cultivation and (?) wild in southern Arizona.

1908. MACDOUGAL, D. T. Course of vegetative seasons in southern Arizona. Pl World 11:189-201, 217-230, 237-249, 261-270.

1908. MACDOUGAL, D. T. Vegetation of Tucson region. Univ. Ariz. Mo. 9:1-18.
Not seen; from Estelle Lutrell's Bibliog. List Books, Pamphlets, and Articles on Arizona in Univ. Arizona Library. p. 34, 1913.

1908. MACDOUGAL, D. T. Botanical features of North American deserts. Carn. Inst. Wash. Publ. 99:1-111, 62 pls.
Conspectus of "desert regions of North America" with abundant references to Arizona, particularly as to the southeastern portion of the state, with much ecological discussion. A digest of principles for the "xerist."

1909. BLUMER, J. C. On plant geography of Chiricahua Mountains. Sci. n. s. 30:720-724.
Detailed comparison with the San Francisco Mountains.

1909. BLUMER, J. C. An Arizona mesa. Pl. World 12:7-10.
"Mesa that lies between Riggs and Bonita canyons," Chiricahua Mts. Discussion of plant associations.

1909. LOWELL, P. Plateau of the San Francisco Peaks in its effect on tree-life. Bull. Am. Geog. Soc. 41:257-270, 365-382, 20 figs.

Illustrations original (which cannot be said of many such articles on plant geography of Arizona!) and often of considerable merit. An account of trees and life-zones about the San Francisco Peaks which are set, "as on a dais," on the Colorado Plateau. Includes an account of trees growing within the crater.

1909. ROSE, J. N. New species of Opuntia from Arizona. Contr. U. S. Nat. Herb. 12:401-402, pl. 55.

1909. SPALDING, V. M. Distribution and movements of desert plants. Carn. Inst. Wash. Publ. 113:1-144.

"Origin of desert floras" (pp. 113-119), a notable chapter. Particular emphasis on "plant associations and habitats" about the Tucson region.

1909. SPALDING, V. M. Cultivated plants in arid Southwest. Pl. World 12:18-21.

Relates to the vicinity of Tucson.

1909. STANDLEY, P. C. New or noteworthy plants from Arizona. Muhlenbergia 5:46-49.

Castilleia and *Machaeranthera*.

1909. STANDLEY, P. C. More southwestern Castillejas. Muhlenbergia 5:81-87.

Castilleia retrorsa and *cruenta*.

1909. THORNBER, J. J. Vegetation groups of the Desert Laboratory domain. Carn. Inst. Wash. Publ. 113:103-112.

1909. THORNBER, J. J. Relation of plant growth and vegetation forms to climatic conditions. Pl. World 12:1-7.

General notes and comparisons between Tucson and Flagstaff.

1910. BLUMER, J. C. An animal factor in plant distribution. Pl. World 13:16-18.

Relation of pocket-gopher *(Thomomys)* to distribution of pines in Rincon Mts. Such papers on biotic factors in geobotany are decidedly infrequent.

1910. BLUMER, J. C. Comparison between two mountain sides. Pl. World 13:134-140.

Between east and west sides of Rincon Mts. in its plant associations.

1910. GRIFFITHS, D. Protected stock range in Arizona. U. S. Dept. Agric Bur. Pl. Indust. Bull. 177:1-28, 6 pls.

Notes on changes in vegetation over a fenced area (*ca.* 50 sq. mi.), mentioning species, on Coronado National Forest, southeastern Arizona. Considers *Isocoma coronopifolia* as a range weed and *Lupinus arizonicus* as a loco-weed, among others.

1910. SHREVE, F. Rate of establishment of giant cactus. Pl. World 13:235-240.

1910. SPALDING, V. M. Plant associations of the Desert Laboratory domain and adjacent valley. Pl. World 13:31-42, 56-66, 86-93.
"Reprinted in part, with revision, from Publication 113 of the Carnegie Institution of Washington" of 1909.

1910. THORNBER, J. J. Grazing ranges of Arizona. Univ. Ariz. Agric. Exper. Sta. Bull. 65:245-360, 12 pls.
"Rainfall and forage map of Arizona" is clear and sufficiently detailed to be floristically useful. Chapter Two treats of "Forage plants. . . and their relation to rainfall" enumerating species.

1911. BLUMER, J. C. Notes on distribution of Castilleja on the Mexican boundary. Muhlenbergia 7:65-71.

1911. BLUMER, J. C. Change of aspect with altitude. Pl. World 14:236-248.
On Tumamoc Hill near Tucson, Santa Catalina, Chiricahua, and Santa Rita mountains.

1911. CANNON, W. A. Root habits of desert plants. Carn. Inst. Wash. Publ. 131:1-96, 23 pls.
Thirty-eight annual and twenty-three perennial species discussed, chiefly of Tucson region, grouped by habitat.

1911. SHREVE, F. Establishment behavior of Palo Verde. Pl. World 14: 289-296.
Discussion of physical liabilities of establishment of *Parkinsonia microphylla*.

1911. THORNBER, J. J. Plant acclimatization in southern Arizona. Pl. World 14:15-23.
Of cultivated species in vicinity of Tucson.

1912. BLUMER, J. C. Notes on the phytogeography of the Arizona desert. Pl. World 15:183-189.
Plants of Cababi, Comobabi and Quijotoa mountains west of Tucson.

1912. BLUMER, J. C. Euphorbias of Tucson and vicinity. Muhlenbergia 8:97-102.

1912. GOODDING, L. N. New southwestern ferns. Muhlenbergia 8:92-94.
Regarding identity of these species see Maxon, Am. Fern Jour. 3:109-116. 1913.

1912. MACDOUGAL, D. T. North American deserts. Geog. Jour. 39: 105-120, 8 pls.
Fully documented presentation of factors—genetic, environmental and geographic. An outstanding introduction to any knowledge of floras of arid North America, given in an Arizona setting but of wide usefulness.

1912. SHREVE, F. Cold-air drainage. Pl. World 15:110-115.
Illustrated by Santa Catalina Mts.

1914. SWARTH, H. S. Distributional list of the birds of Arizona. Cooper Ornith. Club Pac. Coast Avifauna 10:1-133.
Map of life zones of Arizona (facing p. 91) of phytogeographic value.

1915. ABRAMS, L. R. Deserts and desert flora of the West. *In* Nature and Science on Pac. Coast (Am. Asso. Adv. Sci. Guidebook). Paul Elder, San Francisco, pp. 168-176.
Brief discussion of the desert regions, character and origin of desert floras and salient species of a few selected Arizona "points of interest."

1915. READ, A. D. Flora of the Williams Division of Tusayan National Forest, Arizona. Pl. World 18:112-123.
Essentially a local flora for northern Arizona "west of Flagstaff and south of Grand Cañon" from elevations of from 5,000 to about 10,000 feet, chiefly in Coconino County.

1915. SHREVE, F. Vegetation of a desert mountain range as conditioned by climatic factors. Carn. Inst. Wash. Publ. 217:1-112, 37 pls.
Correlation of vegetation and climate (esp. as related to altitude gradient) with general floristic factors in the Santa Catalina Mountains.

1916. WOOTON, E. O. Carrying capacity of grazing ranges in southern Arizona. U. S. Dept. Agric. Bull. 367:1-40, pl. 1-10.
Section "character and distribution of forage" (pp. 9-16) carries a discussion of plant associations with careful indication of component species. Deals with the Santa Rita Range Reserve.

1917. REHDER, A. Genus Fraxinus in New Mexico and Arizona. Proc. Am. Acad. 53:197-212.
A revision of six species, with key, five of which occur in either typical or varietal phase in Arizona.

1919. EASTWOOD, A. Early spring at the Grand Cañon near El Tovar. Pl. World 22:95-99.
Running account of prominent or notable plants.

1919. PAMMEL, L. H. Pingue poisoning in Arizona. Am. Jour. Vetern. Med. 14:32.
Poisoning of sheep by *Hymenoxys floribunda*.

1919. SHREVE, F. Comparison of the vegetational features of two desert mountain ranges. Pl. World 22:291-307, 7 figs.
Deals with Pinaleno and Santa Catalina mountains.

1920. CLUTE, W. N. Notes on the Navago [*sic*] Region. Am. Bot. 26: 39-47.
"Description of stations visited" including Nonnezoshe Arch, Navajo Mountain; Endische, Red Rock, Valley, War God, Aspen, and Hidden springs; Red Lake, Marsh Pass, Laguna Canyon and Kayenta.

1920. NELSON, A. Flora of the Navajo Reservation. Am. Bot. 26:48-56, 87-89.
Many of the 152 named species carry precise locality and habitat notes made in the field. With the supplementary Clute paper, this gives a workable local flora.

1921. CLUTE, W. N. Botanizing in the Painted Desert. Am. Bot. 27:1-8.
Notes on conspicuous or interesting plants from Tuba and Moenkopi, Coconino County, to Natural Bridge of Navajo Mt. via Kayenta, Red Lake and Laguna Canyon.

1921. CLUTE, W. N. Midsummer flora of Tuba Oasis. Am. Bot. 27:41-47, 101-104.

Notable annotated list of species.

1921. RYDBERG, P. A. Two new species from Arizona. Am. Bot. 27:61-63.

Eriogonum Clutei sp. nov. and *Forestiera arizonica* (Gray) comb. n. proposed.

1922. NELSON, A. Flora of the Navajo Indian Reservation, II. Am. Bot. 28:20-25.

Supplementary paper with five novelties described in as many genera from Clute's collections.

1922. UPHOF, J. C. T. Die Populus-Arten im Südwesten der Vereinigten Staaten von Nordamerika. Mitteil. Deutsch. Dendrol. Ges. 32:172-175, 2 pls, 1 fig.

Synoptical descriptions with synonyms and distribution of *Populus arizonica, Macdougallii, Wislizenii, Fremontii, Palmeri, texana, trichocarpa,* and *angustifolia* with mention of varieties.

1923. BAILEY, F. M. Birds recorded from the Santa Rita Mountains in southern Arizona. Cooper Ornith. Club Pac. Coast Avifauna 15:1-60.

Portions of the introduction (pp. 8-9) include vegetational notes and associated birds.

1924. ALDOUS, A. E. AND SHANTZ, H. L. Types of vegetation in the semiarid portion of the United States and their economic significance. Jour. Agric. Res. 28:99-127, pl. 1-16.

Deals with Arizona only incidentally. There are 102 "types" described, usually with a close systematic assignment to species. The illustrations are well chosen and of phytogeographic interest.

1924. CAMPBELL, F. M. Fantastic plants of our western deserts. Nat. Geog. Mag. 45:33-40.

Eight illustrations of familiar *Yucca, Dasylirion* and cacti species of southern Arizona.

1924. HANSON, H. C. Study of the vegetation of northeastern Arizona. Univ. Nebraska Studies 24:85-94, 18 figs.

Treatment of vegetational units (after Clements' terminology) of the San Francisco Plateau and Navajo country, their component species and the environmental factors affecting them.

1924. SHANTZ, H. L. AND PIEMEISEL, R. L. Indicator significance of the natural vegetation of the southwestern desert region. Jour. Agric. Res. 28:721-802, 14 pls.

Important phytogeographic studies made in the Gila Valley and at Casa Grande to determine "soil and climatic conditions which are indicated by different types of natural vegetation," considering the composition of floras as vegetational units.

1926. BLAKE, S. F. Two genera of Asteraceae new to the United States. Proc. Biol. Soc. Wash. 39:145.

Genus *Tithonia* (*T. Thurberi* Gray) reported as new to Arizona.

1927. BARTRAM, E. B. Some Arizona mosses not previously reported from the United States. Bryologist 30:45-50.

Distributional notes for 22 species, chiefly from the Santa Rita Mountains.

1927. BLAKE, S. F. A new Hymenothrix from Arizona. Proc. Biol. Soc. Wash. 40:49-50.

Hymenothrix Loomisii described from Ashfork, Yavapai Co.

1927. WHITE, D. Flora of the Hermit shale in the Grand Canyon, Arizona. Proc. Nat. Acad. Sci. 13:574-575.

Uralo-Asiatic aspect of fossil flora and possible Lower Permian age suggested for this formation. Essentially a preview of his detailed paper of 1929.

1928. BARTRAM, E. B. Studies in Funaria from southwestern United States. Bryologist 31:89-96, 2 pls.

Funaria tucsoni, rubriseta and *plano-convexa* described as new from Arizona. Distributional notes given for many additional species, especially for Tucson area.

1928. WHITE, D. Algal deposits of Unkar Proterozoic Age in the Grand Canyon, Arizona. Proc. Nat. Acad. Sci. 14:597-600.

Note on "oldest fossil remains yet brought to light in the Southwest."

1929. BLAKE, S. F. New Asteraceae from the United States, Mexico, and Honduras. Jour. Wash. Acad. Sci. 19:268-281.

Distributional notes or new species described from Arizona in *Solidago, Plummera* and *Actinea*.

1929. CAMPBELL, R. S. Vegetative succession in the Prosopis sand dunes of southern New Mexico. Ecology 10:392-398, 1 pl.

Five stages outlined for *Prosopis* dune succession following moderate grazing on Jornada Range Reserve, Dona Ana Co., N. M., but pertinent to any related Arizona studies.

1929. KEARNEY, T. H. Plants of Lower Californian relationship in central Arizona. Jour. Wash. Acad. Sci. 19:70-71.

Former distribution of plant species about the shores of an ancient Gulf of California, when it had more northern extensions, suggested for present discontinuous distribution among widely unrelated families.

1929. PENNELL, F. W. A new Maurandya from Arizona. Jour. Wash. Acad. Sci. 19:69-70.

1929. SHREVE, F. Changes in desert vegetation. Ecology 10:364-373, 1 pl.

Alteration of perennial populations in vicinity of Tucson over 18- to 23-year periods under protection from grazing.

1929. SWARTH, H. S. Faunal areas of southern Arizona: a study in animal distribution. Proc. Calif. Acad. Sci. 18:267-383, pls. 27-32, text maps.

Division of region into two faunal (and why not similarly floral?) areas: Western Desert and Eastern Plains, west and east of the Santa Rita Mts. The prominent plant species for each area mentioned by common names.

1929. TAYLOR, W. R. AND COLTON, H. S. Phytoplankton of some Arizona pools and lakes. Am. Jour. Bot. 15:596-614, pl. 46-47. ["D 1928" but issued 10 Jan. 1929 acc. Bull. Torr. Club 56:179].

Systematic list of species and an ecological summary for northeastern counties.

1929. WEINBERG, F. Echinocactus hertichii Weinb. nova specie [*sic*] Desert 1:40, 3 photos.

Species named for William Hertrich described from Tortilla and Gila mountains.

1929. WHITE, D. Flora of the Hermit shale, Grand Canyon, Arizona. Carn. Inst. Wash. Publ. 405:1-219, 55 pls.

Subxerophytic fossil flora, predominantly pteridospermous and coniferous, having affinities with the cosmopolitan Permian of Europe and eastern North America as well as Gondwana and Uralian types.

1930. BARTLETT, O. C. Arizona list of dangerous plant pests and plant diseases. Ariz. Comm. Agric. and Hort., Off. State Entom. Phoenix. Reprinted 4 Jan. 1930.

List prepared for field inspectors arranged by host plants.

1930. BONKER, F. AND THORNBER, J. J. Sage of the desert and other cacti. Stratford, Boston. 106 pp, 8 pls.

Popular desert tales, with usually an Arizona setting, sometimes quite insipid, again pleasantly descriptive. F. M. Campbell's illustrations of *Yucca elata* and of *Carnegiea* are exceptionally fine. "Expressly for those who love the flower-tinged panorama of the glorious great out-of-doors."

1930. DEAVER, C. F. Floristic studies in Oak Creek Canyon. Univ. Ariz. M. S. Botany Thesis.

Not seen. Listed in Univ. Ariz. Bull 4[s]:67. 1933. Oak Creek Canyon is (?) presumably canyon of that name on west slope of Sierra Ancha Mts.

1930. FRICK, K. O. Day afield in southern Arizona. Cactus and Succulent Jour. 2:294-295, 2 photos.

Cactizing in the Santa Catalina Mts. with mention of species.

1930. JONES, M. E. Botanizing in Arizona. Contr. Western Bot. 16:1-9. Published and printed by the author. Claremont, Calif.

"List of 1929 plants" chiefly from Arizona (pp. 10-31). All of the seventeen "Contributions" with possible exception of No. 9 are, however, well stocked with Arizona notes. Number 16 contains in particular notes on Ramsey Canyon, Huachuca Mts.

1931. EASTWOOD, A. New species of plants from western North America. Proc. Calif. Acad. Sci. ser. 4. 20:135-160.

Eriogonum pulchrum and *lanosum*, *Delphinium apachensis*, *Amorpha emarginata*, *Aralia arizonica*, *Convolvulus linearilobus*, *Baccharis arizonica*, *Erigeron Kuschei*, *Laphamia arizonica* and *saxicola* described as new from various parts of the state.

1931. FRICK, K. O. Three days afield in southern Arizona. Cactus and Succulent Jour. 2:438-440, 2 photos.

Cacti of Tumacacori Mts. and vicinity of Arivaca.

1931. HOWARD, F. K. Desert ramblers of Arizona. Desert [Plant Life] 3:52, 3 photos.

Chat about a trip to Superstition Mt., east of Phoenix, without botanical value.

1931. KEARNEY, T. H. Plants new to Arizona. (An annotated list of species added to the recorded flora of the state or otherwise interesting). Jour. Wash. Acad. Sci. 21:63-80.

Carefully documented list of species, arranged by families, with precise locality for each. The latest and in many ways the most valuable paper on the flora of the southern and central portions of Arizona.

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New species described among *Amsonia, Phlox, Verbena, Penstemon, Castilleia, Hymenoxys,* and *Porophyllum,* mostly from the author's recent collections in the state.

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From vicinity of Ft. Apache at elevations of from 5000 to 6000 ft.

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Supplementary paper to that of 1931.

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1934. MAIER, E. A. Technical study of genus Eriogonum of Arizona of the family Polygonaceae. Univ. Ariz. M.S. Botany Thesis.
Not seen. From Univ. Ariz. Record 28':19. 1935 with abstract given.

1934. MORTON, C. V. New species of Dudleya from Arizona. Desert [Plant Life] 6:68.
Original publication of *D. collomae* Rose from vicinity of Payson, Gila Co.

1934. OLSEN, P. G. Cacti found in and near Tucson, Arizona. Cactus and Tucson, Official City and County Magazine 7':5, 7-11. March. Reprinted as unannotated list with only common names, thus stripped of all its substance, *in* Cactus and Succulent Jour. 6:59. 1934.
Essentially a catalog of the cacti of southeastern Arizona, with descriptions and distributional notes for each species. Not a mere compilation.

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GEOGRAPHIC INDEX

This is a guide to regional lists and special papers on limited areas (when several references for the area are given) but does not index papers pertaining to single species. Author's name is followed by the year or years under which references for the wanted area will be found.

Atchison Topeka and Santa Fe Railroad route and that of U. S. Highway No. 66: Parry, 1870; Tracy, 1888.

Baboquivari Mountains (Pima County): Jones, 1930; Kearney, 1931; Kearney and Harrison, 1932.

Beaverdam Mountains (Mohave County): Merriam, 1893; Purpus, 1898, 1899.

Bill Williams River: Torrey, 1857; Hoffman, 1877.

Black Mesa Forest Reserve, see Mogollon Mountains.

Camp Verde, see Fort Verde.

Casa Grande (Pinal County): Shantz and Piemeisel, 1924.

Chiricahua Mountains: Torrey, 1857; Toumey, 1895; Blumer, 1908, 1909; Jones, 1930; Kearney, 1931.

Clifton (Greenlee County); Davidson, 1904-1907.

Cochise County: Nelson, 1885.

Coconino County: Read, 1915.

Comobabi Mountains (Pima County): Blumer, 1912.

Fort Apache (Apache County): Britton and Kearney, 1894; Reagan, 1932.

Fort Huachuca (Cochise County): Britton and Kearney, 1894.

Fort Mohave (Mohave County): Coues, 1866; Cooper, 1869.

Fort Verde (Yavapai County): Britton, 1889; Toumey, 1892.

Fort Whipple (Yavapai County): Coues, 1866.

Gila Valley: Shantz and Piemeisel, 1924; Kearney, 1931.

Grand Canyon: Parry, 1868; Gray, 1885; Lemmon, 1888; Townsend, 1893; Cannon, 1906; Vries, 1907; Abrams, 1915; Eastwood, 1919; White, 1927, 1928, 1929.

Greenlee County: Davidson, 1904, 1905, 1906, 1907; Rixon, 1905.

Hopi Indian Reservation (Navajo County): Hough, 1897, 1898.

Huachuca Mountains: Lemmon, 1883; Britton and Kearney, 1894; Swarth, 1904; Jones, 1930.

Mazatzal Mountains (Gila-Maricopa County line): Kearney and Harrison, 1932.

Mogollon Mountains (chiefly Yavapai County): Britton, 1889; Rusby, 1889; Plummer, 1904; Breen, 1906.

Mule Mountains (Cochise County): Kearney, 1931.

Navajo Indian Reservation (Apache, Navajo, and Coconino counties): Matthews, 1885; Clute, 1920; Nelson, 1920; Clute, 1921; Nelson, 1922; Hanson, 1924.

Phoenix: Kunze, 1903.

Pinaleno Mountains (Graham County): Shreve, 1919.

Quijotoa Mountains (Pima County): Blumer, 1912.

Rincon Mountains (Pima County): Blumer, 1910.

San Francisco Mountains: Rusby, 1882; Britton, 1889; Rusby, 1889; Merriam, 1890; Townsend, 1893; Leiberg, 1904; Cannon, 1906; Lowell, 1909; Hanson, 1924.

Santa Catalina Mountains (Pima County): Lloyd, 1907; Shreve, 1915, 1919; Frick, 1930; Kearney, 1931.

Santa Rita Mountains (Santa Cruz County): Wooton, 1916; Bailey, 1923; Bartram, 1927; Swarth, 1929.

Sierra Ancha Mountains (Gila County): Deaver, 1930.

Sierra Estrella (Maricopa County): Kearney, 1931.

Tinajas Altas Mountains (Yuma County): Kearney, 1931.

Tucson: James, 1881; Spalding, 1907; MacDougal, 1908; Spalding, 1809, 1910; Bartram, 1928; Shreve, 1929; Olsen, 1934.

Tumacacori Mountains (Santa Cruz County): Frick, 1931.

Virgin Mountains (Mohave County): Merriam, 1893; Purpus, 1898, 1899.

Williams: Read, 1915.

Yuma County: Torrey, 1857; MacDougal, 1904; Kearney, 1931.

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An Interesting "Dadoxylon" from Northern Illinois*

Ernest L. Miner

The object of this report is to record an interesting piece of fossil wood from the coal beds of northern Illinois. The specimen was collected in the spring of 1934 by the writer in company with Dr. Waldo E. Steidtmann during a collecting trip to the coal fields of east central and northeastern Illinois. It was found on the dump heap of the Northern Illinois Coal Co., several miles north of Braidwood, Will County; and a few miles east of Coal City, Grundy County, Illinois.

This locality is in the eastern part of the Coal City-South Wilmington field of District No. I (Cady, 1915). The coal bed in this field is the so-called No. 2 vein (Noé, 1925, 1930; Cady, 1915) and is wide spread throughout this region. The shale above the coal contains fossil-bearing nodules or concretions, and many of these were collected from the dump heap along with the specimen of fossil wood. A few of the most common plants found in these concretions were, *Annularia stellata, A. radiata, A. sphenophylloides, Sphenophyllum emarginatum, Lepidophyllum majus, Neuropteris rarinervis, N. decipiens, Pecopteris vestita, P. Miltoni, P. unita, Alethopteris Serlii,* and others.

White (1907a, b, 1908) made a preliminary study of the Paleozoic plants of Illinois; as a result of his observations the Pennsylvanian system in that state was divided into the Pottsville, Carbondale, and McLeansboro formations. Coal bed No. 2 is considered the base of the Carbondale, and No. 6 the top-most member. Noé (1925) has made a more complete study of the fossil flora of northern Illinois. From a comparison of the Pennsylvanian plants of Illinois with those of the Upper Carboniferous of Europe (Noé, 1930) the No. 2 coal seam (Carbondale) has been correlated with the uppermost Westphalien of Europe, and the Pennsylvanian formations above No. 2 with the Stephanien.

The specimen of fossil wood was about the size of one's fist and formed the center core of a gray limestone rock which was over a food in diameter. The wood was calcified, and the preservation varied from good to poor in different parts of the material. A solid covering of calcium carbonate crystals, a little over one sixteenth of an inch thick, encased the whole specimen; in some places this intruded into the material causing some distortion and destruction of the wood. Small masses or mats of leaves and other plant remains were embedded in various parts of the rock, among which could be recognized such genera as *Pecopteris* and *Neuropteris.*

The wood is all secondary and Cordaitean in character; and, for the

* Papers from the Biological Laboratories of Weber College.

present, will have to be relegated to the form-genus *Dadoxylon;* although it differs slightly in ray seriation from that of the genus as defined by Seward (1919). In *Dadoxylon* the rays are uniseriate or partly biseriate but never fully biseriate or partly triseriate. These latter types of ray seriation are found in certain parts of the specimen to be described here, but they are apparently not of a normal occurrence.

In some portions of the wood the cell structure is regular and of the ordinary type, but in other parts it is very irregular. This latter condition is apparently traumatic or else is such growth as may occur around a knot or burl. The preservation is best in or near this irregular part of the wood, which leads to the conclusion that the specimen may be a portion of a knot or some of the adjacent tissue. Knots and the adjacent wood in living trees are usually much harder and more resistant to decay than the remainder of the wood.

The irregular part of the wood is best seen in tangential view. The tracheids instead of being entirely straight show various forms of growth; some are wavy (Fig. 1); some form Y-shaped figures or forks (Figs. 2 and 7); and some are apparently concentric in growth (Fig. 3). The rays in these regions are broader than in the regular portions and vary all the way from uniseriate or partly biseriate to fully biseriate or partly triseriate. These latter types of rays are very uncommon in occurrence.

In the identification of fossil wood the question always arises as to what characters are diagnostic and the extent of variation that they should show in order to arrive at generic or specific determinations. This is especially true when the primary structures are absent or can not be made out with certainty. The criteria that have been used, and no doubt the only ones that can be used in the identification of secondary wood, are the presence or absence of growth rings, the seriation and other characteristics manifested by the pits on the tracheids, the height and seriation of the rays, the length of the ray cells and their lateral pitting, resin cells, and resin canals. Cell measurements for identification purposes are of little value, unless as Desch (1932) indicates they are taken from a large number of specimens; but this is almost impossible when dealing with fossil woods for usually only a single specimen exists from a given locality or horizon. Then allowance must also be made for the partial decay that has occurred in a more or less marked degree in most specimens of fossil wood. The amount of decay gives various differences in wall thickness and cell size.

The works of Von Mohl (1862), Schacht (1862), Holden (1917), Bailey (1933), and others have shown that there is considerable structural variation in the woods of a single genus, species, or even the same plant. It seems, then, that for purposes of identification all of the above mentioned criteria should be used and emphasized according to their value; for the determination of fossil wood is largely a question of relative values. The writer is wholly in accord with the opinion of Bailey (1933, pp. 155) that

> In the present status of our knowledge concerning the variability of diagnostic criteria, specific names as applied to fossil woods have no significance other than as

aids in designating particular specimens. The word "species" must be used in an entirely different sense from that in systematic botany. The failure to recognize this fact has led to much confusion and to numerous misleading generalizations.

In the laterature the names *Dadoxylon* and *Cordaites* have apparently been used interchangeably for Cordaitean wood of the araucarian type, regardless of whether the primary xylem was present or absent. In *Cordaites* the secondary xylem is similar to that of the genus *Mesoxylon*, the differences between the two genera being mainly in the structure of their primary xylem (Scott and Maslen, 1910; Maslen, 1911; Seward, 1917). When dealing with fossil woods of this type, in which the primary xylem is absent or its exact structure is unknown, it seems best that they should be referred to the noncommital genus *Dadoxylon*.

Dadoxylon Steidtmannii sp. nov.

Figs. 1-7.

Growth rings apparently absent; xylem composed entirely of tracheids and rays; tracheids rather uniform in size and shape, 14-42 x 20-70 μ in diameter, average being about 25-35 μ in diameter; bordered pits in 1-3 rows (mostly 1-2) on radial walls of tracheids, pits alternately when in 2 or 3 rows, sometimes crowded and hexagonal; pit orifice an oblique slit, ¾ the diameter of the pit; tangential walls apparently unpitted; rays numerous, 1-30 cells high, mostly uniseriate, or biseriate in part, occasionally fully biseriate, or partly triseriate; ray cells all of one kind, mostly rectangular, 14-35 μ high, 35-98 μ long, extending over 1-3 tracheids, lateral pitting 1-2 pits per tracheid. — Base of Carbondale formation, middle Pennsylvanian; north of Braidwood, Will County, Illinois.

No doubt all of the measurements given above are slightly greater than they should be because of the partial decay of the wood that has taken place during petrification. The bordered pits apparently were more crowded and hexagonal in some instances than they now appear to be. The orifices of the bordered pits are oblique slits, about equal to three-fourths the diameter of the pits. Occasionally opposing slits can be seen, giving them the appearance of the letter X. The lateral pitting of the ray cells could only be made out with certainty in a few places, but in these instances there were only 1-2 pits per tracheid.

The rays in the normal region are narrow, uniseriate or partly biseriate; but as stated before it is only in irregular regions that the wholly biseriate or partly triseriate rays occur (Figs. 1, 2, 3, 7). Although some of the rays are 30 cells high, the great majority of them are much less than that, usually between 1-12. In many of the ray cells there is present a brown substance which is quite distinctly contracted away from the cell walls. It is impossible to tell whether this is a natural resinous deposit or a result of decay during fossilization. Resin canals are apparently absent from both the regular and irregular portions of the wood.

If just the regular or normal aspects of the specimen are considered it resembles very closely *Dadoxylon douglasense*, recently described by Steidtmann (1934) from the Douglas formation (Pennsylvanian) of Kansas. It

conforms in some respects to Penhallow's (1900) descriptions of certain species of *Dadoxylon* and *Cordaites*. Many of the species placed by Penhallow (1900) in the genus *Cordaites* should have been put into the genus *Dadoxylon*, as Seward (1917) indicates, because in the absence of the primary xylem it is impossible to determine whether the wood is *Cordaites* or *Mesoxylon*.

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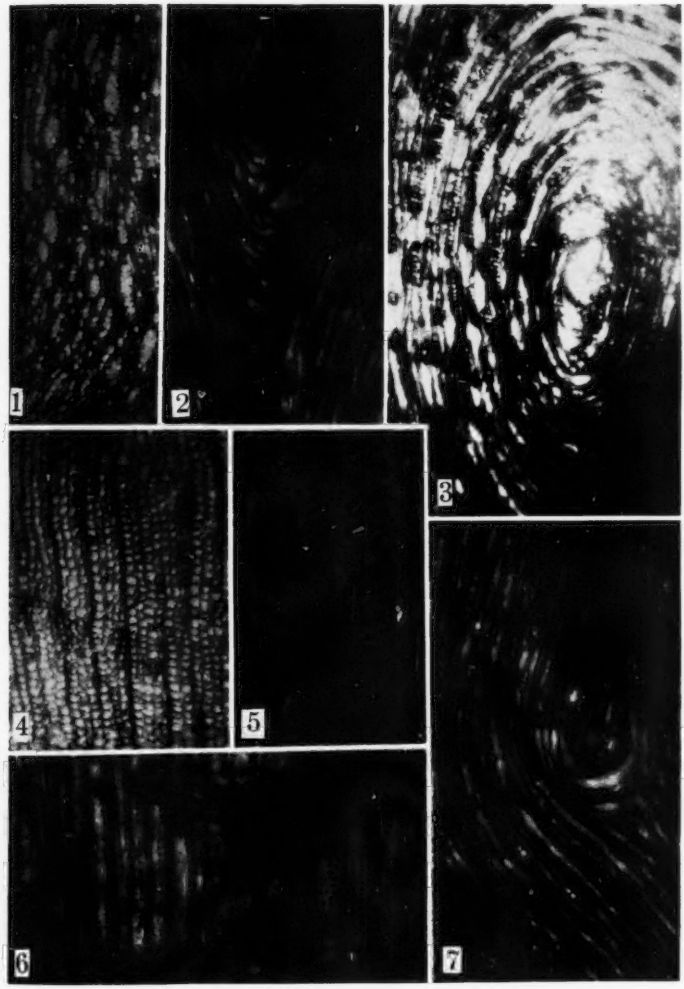


Fig. 1-7. *Dadoxylon Steidtmannii* sp. nov. Fig. 1. Tangential section showing the character of the rays in a portion of the irregular part of the wood. x55. Figs. 2, 3, 7. Tangential sections showing some of the irregular growth of the tracheids. x 55. Fig. 4. Transverse section. x55. Fig. 5. Radial section of a portion of two tracheids showing the bordered pits with the oblique pores. x325. Fig. 6. Radial section. x95.

Structure of Ceratobulimina

Helen Jeanne Plummer

The large size and the abundance of tests of *Ceratobulimina eximia* (Rzehak) in Claiborne (middle Eocene) strata in central Texas offer excellent opportunity to observe the fundamental details of internal structure of tests of this genus of Foraminifera. The delicacy of its minute features and the thinness of the shell matter composing them render observations somewhat difficult, since few specimens remain intact even after the most careful washing of samples containing them. Compact clays rich in this species have yielded many fresh and perfect tests, some of which have been carefully broken to reveal the inner structure of the chambers. After studying the robust Claiborne species, well-preserved specimens of *C. cretacea* Cushman and Harris of the Navarro formation and *C. perplexa* (Plummer) of the Midway group of strata were studied and found to carry the same structure.

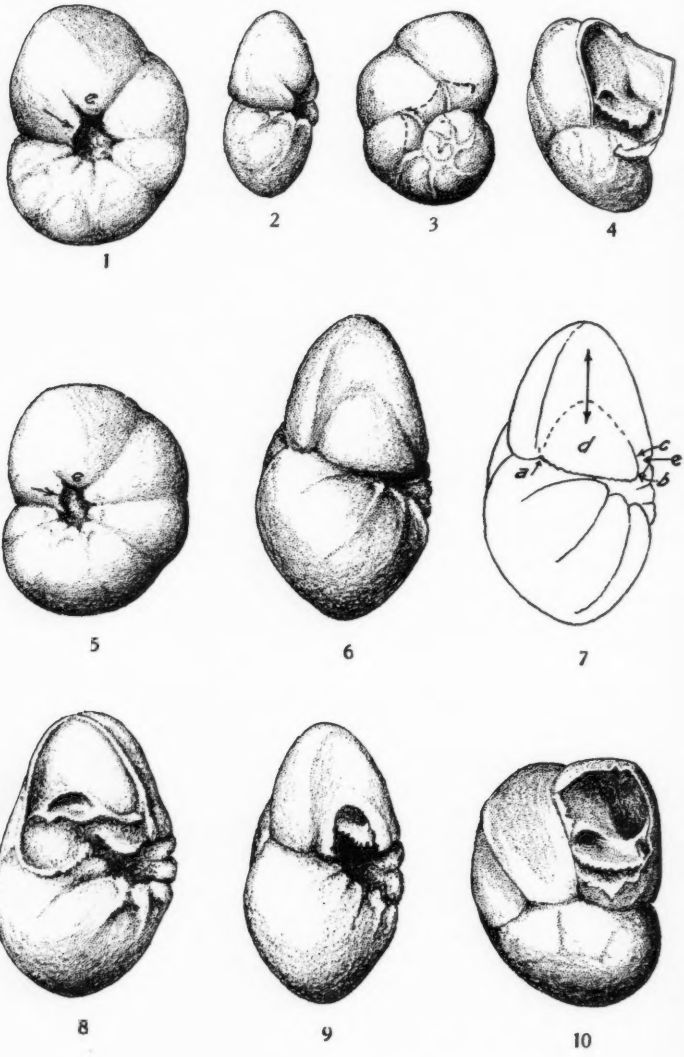
The final chamber of a ceratobulimine test is characterized by a thin wall, which on some specimens is so nearly transparent as to permit a view of the features of the inner structure without breaking away the outer wall. The apertural face is especially thin, and its lower half is characterized by a still thinner and faintly bulging area, at the end of which is the true aperture of the test. In *Ceratobulimina eximia* the long axis of the semi-lunar bulging area coincides with the long axis of the face (double-headed arrow, Fig. 7), and the aperture is a very narrow slit along the base of the face (at base of bulging area). The slit lies over part of the ventral side of the previous whorl and over part of the umbilicus, and it extends from a notch near the periphery (Fig. 7, *a)* to another notch on the edge of the umbilicus (Fig. 7, b*)*. The notch near the periphery marks the ventral end of the line of attachment of the final chamber to the previous whorl of the test. The umbilical notch marks the lower end of a fold that anchors an inner chamber partition to the ventral side of the septal face. In *C. cretacea* and in *C. perplexa* the axis of the bulging area is almost at right angles to the long axis of the septal face and is directed into the umbilicus (arrow, Figs. 1, 5). The bulging area is bounded on one side by the line of attachment of the final chamber to the previous whorl and on the other by the strong umbilical notch and dent (Figs. 1, 5). The aperture of each of these two species lies, therefore, in the umbilicus and at the end of the bulging area.

The septal face of each of the three fossil species under observation exhibits a distinct dent that extends from the notch in the edge of the umbilical depression diagonally across the lower and ventral side of the face and along one side of the bulging area. When the dorsal wall of the final chamber is broken away (Figs. 4, 9, 10), the sharp dent is found to mark the position of a fold that acts as the ventral attachment of a delicately serrate "shelf" or incomplete partition that hangs from the final septum below the transversely elliptical foramen and extends laterally across the septum to the dorsal suture, where it narrows to a point and where it shows externally on many

specimens of these species by a thickening of the suture line to form a slight angulation in its contour (Fig. 3.). The loose edge of the partition curves gently downward toward the previous whorl and toward the apertural opening. The broad ventral end of partition, which is attached to the base of the lobe posterior to the notch (*e* in Figs. 1, 5, 7) and to the septal face by the fold along the line of the external dent, hangs over the apertural opening of the test (Figs. 9, 10). The main part of the final chamber is thus separated by a downward-sloping, shelf-like partition from a small vestibule that is covered by the bulging area of the septal face. From the earlier chambers of the test the protoplasm must flow through the last foramen into the main part of the final chamber, which lies above the partition. To pass out of the test, it must then flow largely over the narrow dorsal end of the downward-curving partition and into the small vestibule that leads to the aperture. It is reasonable to suppose that the internal structure of the final chamber is a protective device to prevent too ready exit of the protoplasm from the shell.

As a new chamber is added and as the final chamber becomes a penultimate chamber, a foramen develops about midway in the septal face that is becoming a septum. The shelf-like partition is then built forward to meet the base of the new foramen and becomes attached to the posterior side of the new septum, thus forming a complete division of the new penultimate chamber from the umbilical side of the chamber to the dorsal end of the foramen. The partition remains incomplete between the dorsal end of the foramen and the dorsal suture, which it meets in a point and in a faint downward-curving fold that shows externally as a slight thickening of the shell wall and forms a faint angulation of the dorsal suture. The general profile of the partitions between successive foramina within the last three chambers of a test is shown by the dotted line in Figure 3.

Since the final chamber of a ceratobulimine test is likely to be very fragile, most tests in a washed sample exhibit the characters shown in Figure 8. The conspicuous final foramen, so commonly exposed on such broken tests has frequently been interpreted as the true aperture, which in perfect specimens is said to be covered by a gently convex protective plate. That no definite and distinct aperture exists in the septal face beneath its convex area is obvious from a careful examination of a large number of specimens. The lower bulging area of the face merely covers the broad end of the serrate chamber partition (Fig. 9) and comprises the outer wall of the vestibule. The external dent extending from the umbilical notch diagonally across the ventral side of the face is in no species an opening, but on the contrary marks consistently the line of attachment of a strong fold at the ventral end of the inner partition to the septal face. This end of the partition is complete across the ventral side of the chamber and closes off the umbilical lobe of the chamber (*e* in Figs. 1, 5, 7). The direction of the notch and dent has suggested a relationship of ceratobulimine tests to the family *Cassidulinidae*, which is characterized by true apertures that lie in a similar position in the septal face. In *Ceratobulimina* the notch lies at the posterior end of its true apertural opening (end of arrow, Figs. 1, 5; slit from *a-b*, Fig. 7) but can not comprise the aperture. It was natural that Reuss, with poorer optical facilities, should have figured



1 2 3 4

5 6 7

8 9 10

and described this deep notch as the true aperture of *Rotalina contraria*, since it is the most conspicuous feature of the septal face. No topotypes of his species have been available for study. The original figure, however, is so typical of the rotaliform coil of all ceratobulimine tests under observation, and its "aperture" is so characteristic of the straight, tapering notch and dent in these tests, that it is reasonable to assume that *Rotalina contraria* Reuss in the Oligocene strata at Hermsdorf is characterized by a true slit-like aperture, which is either along the base of the septal face as in *Ceratobulimina eximia* (Rzehak) of Texas Claiborne strata (and this is the more likely position), or in the umbilical depression as in *C. cretacea* Cushman and Harris and in *C. perplexa* (Plummer). The structure and apertural characters of *Ceratobulimina* as here described and figured place the genus in the family *Rotaliidae*.

FIGURES

1-4. *Ceratobulimina perplexa* (Plummer), x100. From Midway outcrop in east bank of a small tributary to Tehuacana Creek, 2 miles north and a little east of Mexia, Limestone County, Texas.

1. Ventral view showing conspicuous umbilical notch and dent between the closed ventral lobe (*e*) of the final chamber and the bulging area elongated in the direction of the arrow. The aperture of the test lies at the end of the arrow.
2. Peripheral view of a test.
3. Dorsal view showing by the dotted line the profile of the partitions between the successive foramina.
4. View into the final chamber of a test showing the position of the fold that marks the external dent and position of the serrate, shelf-like partition that meets the dorsal suture in a point.

5. *Ceratobulimina cretacea* Cushman and Harris, x100. From an outcrop of Navarro strata on Colorado River at Webberville, Travis County, Texas. This shows the same ventral features that characterize *C. perplexa*, and the species is differentiated by its thicker test.

6–10. *Ceratobulimina eximia* (Rzehak), x100. From an exposure in a road ditch, 0.15 miles northeast of the steel bridge over Boggy Creek and 0.7 miles south of Middleton post office, Leon County, Texas.

6. Peripheral view of a typical and perfect test.
7. Outline of the same test showing salient features in the structure: *a*, notch at ventral end of attachment of final chamber to previous whorl; *b*, umbilical notch between the bulging area *d*, and the ventral lobe of the chamber *e*; *c*, dent that extends from the notch diagonally across the ventral side of the septal face and along the ventral side of the bulging area. The double-headed arrow marks the elongate axis of the septal face and of the bulging area. The true aperture of the test is the slit between *a* and *b*.
8. Test from which the final chamber has been broken away during the washing of the sample, the most common condition of tests. The inner partition of the chamber has been broken off, but the view shows where it was attached to the septum below the foramen.
9. Peripheral view of a specimen from which the wall of the bulging area of the septal face has been partially removed to show the serrate, shelf-like partition.
10. View into a final chamber showing the position of the partition and the fold that anchors its ventral end to the ventral face along the line of the external dent.

A Miocene Pearl

Charles T. Berry

While working at the Maryland Academy of Sciences this past winter I found the specimen that forms the basis for the present article. It was collected a number of years ago from the Choptank formation a little north of Jones Wharf, St. Mary's County, Maryland, by John Widgeon, and represents a large blister pearl attached to the shell of *Panopea americana*. Before taking up the question of fossil pearls it is well to review briefly the different types of recent pearls and how they are formed. After which I will discuss the blister pearl in question.

The pearls used for commerce are taken almost wholly from bivalve mollusks of which the three most important families are the *Aviculidae*, the *Mytilidae*, and the *Unionidae*. The first includes the true pearl oyster of the Pacific and Indian Oceans; and the last—the *Unionidae*—are the fresh water clams. Many other species of pelecypods furnish us with pearls, as well as a few of the gastropods, but it is these three families which are sought by the pearl fisheries.

In general, pearls consist of very thin concentric layers of nacreous mother-of-pearl interstratified with animal membrane. Refraction of light rays from these nacreous layers gives the pearl its luster.

Pearls are divided into two groups according to their origin, the true pearls and the blister or baroque pearls. The blister pearls can be grouped into two divisions according to their origin. First, those caused by the perforation of the shell by boring worms, sponges and predatory bivalve mollusks; second, those caused by some foreign particle which has become intruded between the mantle and the shell. In the first condition the pearl oyster strives to seal over the hole and as the parasite continues to attack the shell, the host continues to build up layer upon layer of nacreous material thus forming a blister pearl. The second condition is similar to that of the formation of a true pearl except that it is formed adjacent or attached to the shell.

Not all pearls are the same in structure or substance regardless of their shape or whether they are secreted by the same genera of lamellibranch. This is dependent partly upon their position in the shell. H. L. Jameson [1] divides them into five types:

1. Nacreous pearls
2. Prismatic pearls
3. Periostracum pearls formed in the mantle margin
4. Pearls formed of the muscle substance
5. Pearls formed on the hinge ligament substance

[1] Jameson, H. L., On the Origin of Pearls. Proc. Zool. Soc. London, **1**:146, 1902.

Thus it is obvious that there is a very great variety of pearls, excluding the question of shape and color.

The fossil specimen was collected from the lower part of the Choptank formation just north of Jones Wharf, St. Mary's county, Maryland. The Choptank formation is the middle member of the Chesapeake group as found in Maryland and is of Miocene age. The Choptank formation has been correlated with the Tortonian stage of Europe by T. W. Vaughan [2].

The genus *Panopea*—often spelled *Panopaea* or *Panope*—is placed in the family *Saxicavidae*. Their shells are in general very large, some reaching a length of 10 inches. The shells are not nacreous in the sense that those of *Avicula* are. The number of species of *Panopea* is limited and they chiefly inhabit cold waters. They have, however, representatives in the warm waters of the Mediterranean Sea. They are found in the cool waters of the northern hemisphere and a few in the southern hemisphere. Fossil species are recorded from the Cretaceous to the present. In Maryland, they are very numerous throughout the Miocene, *Panopea americana* being predominatingly confined to the Choptank formation.

Viewing, first, the external surface (Fig. 1) of this left valve of *Panopea americana* Conrad there appears to be no irregularity in the configuration in the growth lines and there is no minute circular hole on the external surface which would indicate the former presence of some boring bivalve mollusk or the like. Thus the external surface is that of a normal *Panopea* shell with no irregularities.

This left valve is 173 mm. long, 107 mm. high and has a diameter of 37 mm. (left valve). By comparing the interior views of Fig. 2 and Fig. 3, —the latter which is an inside view of the specimen from Plum Point illustrated in the Maryland Miocene volume [3]—one is able to see that the specimen in question is of average size for this species being however, a little larger that that from Maryland. This is further brought out by comparing the measurements of the two shells.

	Length	Height	Diameter
Jones Wharf	173 mm.	107 mm.	37 mm.
Plum Point	161 mm.	92 mm.	32 mm.
difference	12 mm.	15 mm.	5 mm.

On the internal surface (Fig. 2) of the left valve of *Panopea americana* from Jones Wharf the first thing which strikes the eye is the large internal growth or blister pearl. This internal growth is located in the posterior portion of the shell. It is 59 mm. long, 40 mm. high, and about 19 mm. thick. In taking these measurements I paralleled the same axes that were used in the measurements of the shell. The surface of this growth is undulating with several small rounded pits and protuberances. Several layers of the thin lamellae have been penetrated in places so that I was able to count eight

[2] Vaughan, T. W., Criteria and Status of Correlation and Classification of Tertiary Deposits. Bull. Geol. Soc. Amer. **35**:677-742, 1924.

[3] Md. Geol. Surv., Miocene, pl. lxvi, fig. 2, 1904.

different lamella. This irregularity in surface—due to the exfoliation of several of the outer layers of lamellae—gives this growth a mottled color effect. The color in general is much darker than that of the inside of the shell.

The Plum Point specimen weighed 5½ oz. while the Jones Wharf specimen weighed 8½ oz.; a difference of 3 oz. Since difference in size of the two shells will not account for this, it is safe to say that this growth or pearl weighed about 2 oz. I tapped the growth all over with a pencil and received the same sound, showing that the growth was entirely solid and not hollow in some part. I was very anxious to section this specimen in order to see just what caused this peculiar growth, but I was afraid of ruining a unique specimen.

The interior of the shell is in general similar to that of a normal *Panopea americana* as can be seen by comparing Fig. 2 with Fig. 3. This seems exceedingly unusual for in recent pearl oysters those which contain pearls are often greatly distorted even when the pearl is very minute. One would thus infer that this fossil shell should be greatly distorted since it houses such a large growth. The anterior portion of the shell is normal. The pallial line is very sharp and distinct showing no irregularities. The anterior adductor muscle scar is perfect as to position and condition. It is only when we consider the posterior portion of the shell that we find unusual conditions. The pallial sinus is marked as in a normal specimen being however, a little encroached upon from the dorsal side by the growth. In fact it partly overhangs the dorsal margin of the pallial sinus. Likewise the posterior adductor muscle scar has been encroached upon from the anterior side so much so that it is only about ⅔ of its original length.

What foreign object caused this growth? As I have stated in my discussion of blister pearls in recent forms, there are two possibilities—the first, a boring mollusks or the like. This question can be quickly disposed of by a careful study of the exterior of the valve; there is no evidence whatsoever of any parasite's having attached itself to the shell and penetrating it. Thus there is the other question which must be the answer, that some foreign matter had entered the shell—while open—and had gotten lodged in the dorsal portion. Whether this foreign matter was large or small only a section can show. In some recent oysters small fish have gotten in and have been subsequently entombed in a pearl. If the object in this fossil pearl was minute it must have lodged there for years for the growth to reach the size that it did.

Whether or not the right valve was distorted is hard to say, but I hardly think so for if it were it would have been reflected in the margin of the left valve. The right valve was either, never collected or has since been lost for I have been unable to locate one which would match the left one.

In going over the literature on fossil pearls one finds that there is very little mention made of them. Apparently they have been overlooked by the collectors for in those cases where an account of them has been made there are invariably a number of pearls described. The first instance that I have noted was that of John Woodward [4] in 1723 and the latest is that of Adolph Zilch [5]

on March 1934. Some of the more recent accounts I will briefly outline in chronological order.

Adkins and Winton [6] recorded in 1919 the discovery of several pearls—five in number—from the Walnut clay beds (Comanchean) in Coke County, Texas. These pearls were found within *Exogyra taxana*. These Texas pearls belong to the true pearl group.

In an obscure publication [7] Jackson records the finding of over 130 specimens of pearls. These pearls were grouped together in a cluster "about the size of a small hen's egg," and were found in association with broken shells of *Ostrea* and *Pinna*. Jackson concludes from present conditions that these pearls were formed in *Pinna affinis*.

Russell [8] gives an account of ten pearls from the Chico formation (Cretaceous) of Shasta County, California, and also one from the Cowlitz formation (Eocene) of southwest Washington. Russell has gone to much pains to make sections of several of his Cretaceous pearls and gives a very good account of their character and condition. These pearls were isolated from any shell, except one, which apparently came from—*Inoceramus subundatus*. The Eocene pearl was found in a *Pteria* shell. In both of thes cases the pearls fall under the true pearl group.

F. Haas [9] has written a short account of fossil pearls which amounts to practically a review of R. D. Russell's article. In this article Haas adds nothing to our scant knowledge of fossil pearls, therefore, I will not deal with it any further.

In the most recent paper published on fossil pearls—that of A. Zilch [10]—one finds a very short account of a pearl from the lower Miocene of Klein-Karben, just north of Frankfurt, Germany. The fossil—*Perna sandbergeri*—which contained the pearl, was found in a gravel bed. The pearl which has the shape of a flattened sphere is 3 mm. in diameter. Under high magnification its surface appears to be covered by fine cracks. After the pearl had been removed from the shell there remained a deep crater-like pit. Apparently the *Perna* had not only encased the foreign particle itself, but had later built up its shell so as to nearly cover the entire pearl. This specimen is at present in the Senckenburg Museum.

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4 Woodward, J., An Essay toward a Natural History of the Earth. 3d. ed., p. 24, 1723.

5 Zilch, A., Eine Perle aus der Meereszeit der Wetterau. Ber. d. Senck. Naturf. Gesell. **64**(3):93, 1934.

6 Adkins, W. S., and W. M. Winton, Paleontological Correlations of the Fredericksburg and Washita Formation in North Texas. Univ. Texas Bull. **1945**:54, 1919.

7 Jackson, J. F., Fossil Pearls. Proc. Isle of Wight Nat. Hist. Soc.: 466, 1926.

8 Russell, R. D., Fossil Pearls from the Chico formation of Shasta County, California. Amer. Jour. Sci. **18**(5):416, 1929.

9 Haas, F., Fossile Perlen. Ber. d. Senck. Naturf. Gesell. **61**(3):120, 1931.

10 Zilch, A., Eine Perle aus der Meereszeit der Wetterau. Ber. d. Senck. Naturf. Gesell. **64**(3):93, 1934.

Inoceramus goldfussianus	D	Westphalia, Germany
I. expansus	E	South-East Africa
I. sagensis	F	Burlington, New Jersey
I. subundatus	G	Redding, California
I. labiatus	H	Kent, England
I. sp.	I	Urakawa, Japan
I. sp.	J	Kent, England
I. sp.	K	Kent, England
I. sp.	L	Suffolk, England
I. sp.	S	Cambridge, England
I. sp.	T	Suffolk, England
I. sp.	Y	Bahamas

Distribution of pearl bearing *Inoceramus*
(Note: letters refer to literature cited on next page)

When one studies the above tabulation he finds that these *Inoceramus* which contained pearls were world wide in distribution. They were also all confined to the Cretaceous period, none having been found in the Jurassic period. In all these instances the pearls are of both types—the blister pearl and the true pearl. Apparently *Inoceramus* performed the same function as *Avicula margaritifera* does today, therefore it can be spoken of as the "Pearl

Species	Jurassic	Cretaceous	Eocene	Miocene	Oligocene	Pliocene	Pleistocene
Pinna affinis			A				
Perna oblonga		B					
P. sandbergeri				C			
Inoceramus goldfussianus		D					
I. expansus		E					
I. sagensis		F					
I. subundatus		G					
I. labiatus		H					
I. sp.		I					
I. sp.		J					
I. sp.		K					
I. sp.		L					
I. sp.		S					
I. sp.		T					
I. sp.		Y					
Pteria sp.			M				
Volsella (Modiola) modiolus							N
Ostrea edulis						U	
O. tenera			V				
Gryphaea dilatata	O						
Gryphaea dilatata	W						
Exogyra texana		P					
Lima scabra						X	
Mytilus edulis							R
Panopea americana				Q			

Distribution of Fossil Pearls

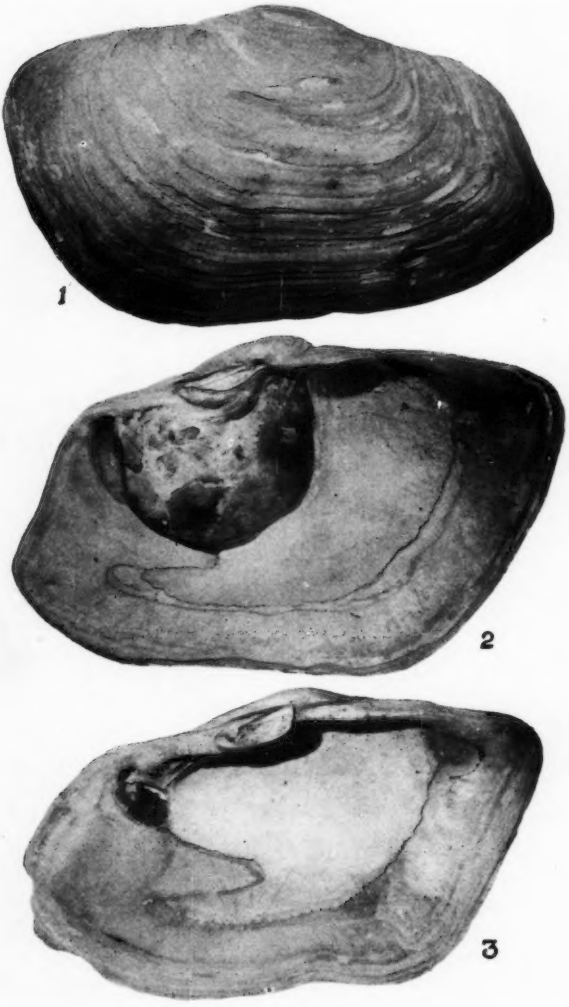

Fig. 1. Exterior view of left valve of *Panopea americana*, from Jones Wharf, M.
Fig. 2. Interior view of left valve of *Panopea americana*, from Jones Wharf, M.
Fig. 3. Interior view of left valve of *Panopea americana*, from Plum Point, Md.
(All figures x 0.5.)

Oyster" of the Cretaceous. This is clearly evident when we recall that *Inoceramus* had a nacreous lining similar to our *Avicula margaritifera*. Thus we have one genus—*Inoceramus*—during Cretaceous time which produced most of the pearls of that period. We have seen that a similar condition prevails today—the best pearls being produced by three families.

A. Jackson, J. F.—Proc. Isle of Wight. Nat. Hist. Soc. p. 466, 1926.
B. Seeley, H. G.—Ann. Mag. Nat. Hist. **7**:121, pl. 6, fig. 6, 1861.
C. Zilch, A.—Ber. d. Senck. Naturf. Gesell. **64**(3):93, 1934.
D. Goldfuss, A.—Petrefacta Germaniae, **2**:116, pl. 112, fig. 4d, 1836.
E. Newton, R. B.—Proc. Mal. Soc. London **8**:133, pl. 4, fig. 2, 3, 1908.
F. Whitfield, R. P.—Mon. U. S. Geol. Surv. **9**:79, pl. 14, fig. 16, 1885.
G. Russell, R. D.—Amer. Jour. Sci. **18**(5):416, 1929.
H. Newton, R. B.—idem., 135, 1908.
I. Yokoyama, M.—Palaeontographica **36**:175, pl. 18, fig. 6, 1890.
J. Morris, J.—Ann. Mag. Nat. Hist. **8**:89. pl. 4, fig. 12, 1851.
K. Newton, R. B.—idem., 135, 1908.
L. Newton, R. B.—idem., 136, 1908.
M. Russell, R. D.—idem., 425, 1929.
N. Robertson, D.—Trans. Geol. Soc. Glasgow **7**(1):31, 1883.
O. Morris, J.—idem. **89**, pl. 4, fig. 16, 1851.
P. Adkins, W. S. and W. M. Winton—Univ. Texas Bull. **1945**:64, 1919.
Q. Berry, C. T.—(see page 464).
R. Jackson, J. W.—Proc. Mal. Soc. London **8**:318, pl. 14, fig. A, B. 1909.
S. Jackson, J. W.—idem., 318, pl. 14, fig. C, 1909.
T. Jackson, J. W.—idem., 318, pl. 14, fig. D, 1909.
U. Jackson, J. W.—idem., 319, pl. 14, fig. E, 1909.
V. Jackson, J. W.—idem., 319, 1909.
W. Jackson, J. W.—idem., 319, 1909.
X. Jackson, J. W.—idem., 319, 1909.
Y. Morris, J.—idem., 89, pl. 4, fig. 13, 14, 1851.

The preceding table shows the distribution of all the fossil pearls that I have found mentioned in the literature. There are twenty-four such instances. It is interesting to note that there are two other species of lamellibranchs besides *Inoceramus* in the Cretaceous from which pearls have been reported. The apparent absence of pearls from the Oligocene is due either to their actual rarity or more probably to lack of discovery.

The Miocene period has apparently supplied the largest of fossil pearls in the specimen just described and one which probably rivals or exceeds any of the recent ones. This blister pearl was never as lustrous as if it had been formed in a true pearl oyster. Instead its luster was probably dull because its host was one which did not secrete a nacreous lining to its shell. The shell in which this pearl was formed is *Panopea americana* Conrad and was collected from the Choptank formation at Jones Wharf, Maryland. Unlike all other pearl bearing bivalves the shell of this *Panopea* was not in the least distorted. Undoubtedly the foreign matter which caused the building up of such a large blister pearl entered the animal at some time when the shell was open. There is no evidence on the exterior of the shell to show that the foreign matter had penetrated through the shell.

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The Atlantic and Gulf Coast Tertiary Pectinidae of the United States *

H. I. Tucker

I.—Acknowledgments

The writer is indebted to Dr. Paul Bartsch, of the United States National Museum, for permission to study the type specimens in the collections of the Museum; to Dr. R. E. L. Collins, of The Johns Hopkins University, for the privilege of studying the type specimens in the collections of the University; to Dr. H. Pilsbry, and Mr. E. G. Vanatta, of the Academy of Natural Sciences of Philadelphia, for assistance given in the study of types in the collections of the Academy; and to Professor Emeritus G. D. Harris, of Cornell University, for the privilege of studying the Pectinidae in his Tertiary collections. Dr. H. B. Stenzel, of the Bureau of Economic Geology, Austin, Texas, kindly lent the writer specimens from his collection of Eocene fossils.

The Academy of Natural Sciences of Philadelphia, Rutgers University, The American Museum of Natural History, The United States National Museum, The Linnean Society of London, and the British Museum of Natural History have very kindly had photographs made of specimens in their collections for purposes of illustration and comparison.

Dr. L. R. Cox, of the British Museum of Natural History, Dr. J. Marwick, of the New Zealand Geological Survey, Dr. D. L. Frizzell, of Stanford University, Dr. W. C. Mansfield, of the United States Geological Survey, Prof. G. Stefanini, of the University of Pisa, Prof. H. Gerth, of the University of Amsterdam, and Dr. C. W. Stiles, Secretary of the International Commission on Zoological Nomenclature, have been consulted in regard to various problems which are discussed in this paper.

Professor H. G. Schenck, of Stanford University, has read the manuscript and offered valuable suggestions.

II.—Systematic Descriptions

Order PRIONODESMACEA Dall
Section ISODONTA Fischer
Superfamily PECTINACEA Reeve
Family PECTINIDAE Lamarck
Genus PECTEN Müller, 1776

Pecten P. Belon, 1553 (= *Vola* Klein, 1753 = *Janira* Schumacher, 1816); Stoliczka, Geol. Surv. India, Mem. 3:424, 431, 1871, *partim;* Fischer, Man. de Conch.: 946, 1886, places *Vola* Klein in synonymy, cites as type *P. jacobaeus* Linné; Dou-

* This paper forms a portion of the thesis submitted to the Faculty of the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

villé, Soc. Geol. de France, ser. 3: **25**: 202, 1897, cites *P. jacobaeus* L. as type of *Vola;* Ugolini, Paleont. italica, **12**:156, 1906, cites *P. jacobaeus* L. as type.

Pecten Klein, Tent. Meth. Ostrac., 1753.

Pecten Linnaeus, 1758, H. and A. Adams, Gen. Moll., **2**: 550, 1858, *partim*, lists *P. varius* L., *P. pallium* L., *P. maximus* L., etc.

Pecten Müller, Zool. Dan. Prodr.: 248, 1776, *partim*, lists *P. maximus*, L., *P. islandicus* L., *P. irradians* L., etc.; Da Costa, Brit. Conch.: 140, 1778, *partim;* Bolten, Mus. Bolt.: 165, 1798; Lamarck, Mém. Soc. Nat. Hist. Paris, An. **7**:88, 1799; Schmidt, Versuch. Conch. Samml.: 67, 1818, designates as type, *Ostrea maxima* Linné; Tryon, Syst. Conch., **1**:288-89, 1822; Children, Quart. Jour. Sci., **15**:66, April, 1823, designates as type, *Ostrea maxima* Linné; Gray, Zool. Soc. London, Proc., pt. **15**:200, Nov., 1847, designates as type *Ostrea maxima* L.; Woodward, Man. Moll.: 256, 1856, designates as type, *P. maximus (Janira* Schum.); Hörnes, Die foss. Moll. Tert.-Beck. von Wien, **2**, *(Bivalven)*: 393, 1870, *partim;* Woodward, Man. Moll.: 411, 1877; Dall, Mus. Comp. Zool., Bull. **12**:206, 1886, *partim;* G. F. Dolfus, Soc. Geol. de France, Bull., ser. 3, **25**: 203, 1897, cites *P. jacobaeus* L. as type; Sacco, I Moll. dei Terr. Terz. del Piemonte e della Liguria, Parte **24**: (Pectinidae), 53, 1897, cites *P. jacobaeus* L. as type; Dall, Wag. Free Inst. Sci., Trans. **3**: 689, 1898, *partim;* Verrill and Bush, U. S. Nat. Mus., Proc. **20**: 286, 1898, *partim;* Verrill, Conn. Acad. Sci., Trans. **10**: 53-57, 1899, *partim;* Dall and Simpson, U. S. Fish Commission Bull. **1**: 464, 1901, *partim;* Arnold, U. S. Geol. Surv., Prof. Paper **47**: 45-48, 1906, *partim;* Maury, Bull. Am. Pal., **8**: 58, 1920, *partim;* Iredale, Linn. Soc. S. Wales, Proc., **49**: 194, 1924; Oldroyd, Stanford Univ. Publ. **1**: 51, 1924, *partim;* Woodring, Carnegie Inst. Wash., Publ. **366**: 62, 1925, *partim;* Dautzenberg and P. F. Fischer, Trav. Sta. Biol. Roscoff, fas. **3**: 113, 1925, cites as type, *P. jacobaeus* L.; Gardner, U. S. Geol. Surv., Prof. Paper **142**-A: 43, 1926, *partim;* Cox, Rept. Pal. Zanzibar Protect.: 39, 1927; Stewart, Acad. Nat. Sci. Phila., Spec. Publ. **3**: 116, 1930, *partim;* Kennard, and others, Smith. Misc. Coll., **82**: (17): 15, 1931; Grant and Gale, San Diego Soc. Nat. Hist., Mem. **1**: 154, 1931, *partim;* Makiyama, Kyoto Imp. Univ. Mem. Coll. Sci., **10**: (2): 132, 1934; Winckworth, Jour. Conch. **20**: (2): 51, 1934.

Pecten Bruguière, Ency. Meth., 1797; Rang, Man. des Moll.: 288, 1829, *partim;* Swainson, Cab. Cycl.: 388, 1840, *partim;* Chenu, L'Hist. Nat. des An.: 181-82, 1842, *partim;* Sowerby, Conch. Man., 3d. ed.: 217, 1847; Deshayes, An. sans Vert., **2**, 69, 1864.

Genotype.—*"Ostrea" maxima* Linné, by subsequent designation, Schmidt, 1818. Living off the coast of Europe from Norway to the Straits of Gibraltar.

Diagnosis.—Shell usually suborbicular, inequivalve, nearly equilateral; auriculate, inconspicuous byssal sinus; right valve usually more convex than the left; not sessile; hinge straight, with central, internal resilium; in adults there are usually interlocking crural ridges and grooves which diverge from the apex of the resilial pit; monomyarian; simple pallial line; adductor scar rounded, posterior; not lirate internally.

Remarks.—Bolten was the first binomial writer to subdivide *Pecten, s. l.*, and to restrict it. He recognized *Pecten* (type, *P. maxima), Chlamys,* (type, *C. islandicus),* and *Amusium* (type, *A. pleuronectes).*

Schumacher (Essai d'un Nov. Syst., 1818), seemingly ignorant of Bolten's work, divided *Pecten, s. l.* He proposed the name *Janira* for *Pecten, s. s.*, restricted *Pecten* to the group called *Chlamys* by Bolten, and for *Amusium* cited the same type as Bolten had listed.

Stoliczka followed H. and A. Adams in adopting *Pecten* for a large group, with *P. varius* L. as type. *Pecten, s. s.* he called *Vola,* following Klein and H. and A. Adams. Klein, however, placed the one-sided pectens in the first section of his genus *Pecten* and listed as his first species *P. maximus.* Later he gave a brief description of *Vola* as a single "species" of his typical *Pecten.*

Verrill recognized *Pecten* Müller, 1776, and listed as type *P. maximus* L. Dall, however, includes numerous subgenera and sections now recognized as of generic and subgeneric value, as does Arnold. Both cite *P. maximus* as the type of *Pecten.*

Schmidt, (1818) made the first clear designation of genotype:

Gen. 145. Pecten. Oben mit Ohren versehen, ungleichschalig, mit aneinander stossenden Wirbeln. Das Schloss ungezahnt. Das Schlossband innerhalb in einer dreiseitigen Grube. Typ. Ostrea maxima.

Subsequently Children, 1823, and Gray, 1847, made valid designations of genotype, which are available in the event that Schmidt's should for any reason be questioned.

Grant and Gale, 1931, regard the genus *Pecten* as having been established by Osbeck (Dagbok öfver en Ostindisk Resa åren, 299, 1750-52) rather than by Müller. The earliest account of Osbeck's travels were published in Swedish in 1757. J. G. Georgi translated the account into German in 1765, and in 1771 J. R. Forster published an English translation based upon the German of Georgi. The original reference to *Pecten* appears, without changes or additions, in each translation:

1757: 299.

Med ankartaeget sölade et hwitt Corall-äme, hwarpå en rod Snacka, *Pecten adscensionis,* som hade manga grenar på skalet och war fastwächt.

1765: 391.

Mit dem Ankertau ward ein Corallenstück aufgezogen, auf welchem eine rothe Schnecke *(Pecten adscensionis)* angewachsen war, die auf den Schalen sehr viele Aeste zeigte.

1771: 100.

With the cable we pulled up a piece of coral on which a red shell *(Pecten adscensionis)* was growing which on its valves represented many branches.

The first publication of Osbeck's account of his travels is clearly unavailable, under Article 26, International Rules of Zoological Nomenclature. The German translation, although revised, does not give nomenclatorial validity to the original names. Opinion 21, of the International Commission on Zoological Nomenclature, refuses nomenclatorial status to Klein's genera of 1744, as quoted by Walbaum. Even more *à propos* to the question is Opinion 57.—

Hasselquist's 'Iter Palestinum' was published prior to 1758; it was edited as to nomenclature by Linnaeus. The German translation by Gadebusch, published in 1762, does not give validity to names published in the original edition in 1757.

R. Winckworth, Jour. Conch., 20 (2), 1934, states:

Not only is *Pecten* Osbeck inadmissable on this basis, but it would also appear a *nomen nudum.* The genus is in no way described, but is solely dependent on its asso-

ciation with the specific name *Adscensionis*. This species, however, is certainly not indicated or defined, and surely one cannot regard this casual allusion as a description. It is so far from being described that Grant and Gale interpret it as an unidentified species of *Chlamys*, while I should consider it more probable that it was *Spondylus powelli* Smith, after consulting published and manuscript lists of Ascension Island mollusca and bearing in mind the remark, firmly grown (fastwäxt) on coral; though an unknown species of *Chama* might be a better guess. This point could be settled from the actual specimen, which is probably still in existence, but "in no case is the word indication to be construed as including museum specimens."

My conclusion is that *Pecten* Osbeck is a nude name, published in a work not valid for nomenclature; accordingly *Pecten* Müller, 1776 stands with *P. maximus* L. as type.

R. Stewart, Acad. Nat. Sci. Phila., Spec. Publ. **3**:116, 1930, states that:

The earlier use of *Pecten* cited by Sherborn (Ind. Anim., p. lx) is practically a *nomen nudum* and should not affect the later use of that name. *** Doubtless something can be said for regarding it as a *nomen dubium*, in which case it would invalidate *Pecten* Müller.

In no sense do the 1765 (Georgi) and 1771 (Forster) translations appear to be systematic revisions, and cannot, therefore, validate the name under Opinion 5. The 1765 translation should be regarded merely as a *translation* and analogous to that of Hasselquist ruled out by Opinion 57. Grant and Gale consider that it should rank as a distinct work, since certain additions were made in the German version by Osbeck himself. The question whether a *revised* edition should rank as a distinct work in such cases seems not to be covered by any opinion yet rendered.

Dr. L. R. Cox, of the British Museum, in a personal communication dated May, 1934, states that:

Pecten adscensionis just misses being a *nomen nudum* as it is said to red, with many branches on the shell, but it is certainly a *nomen dubium*. It is said to be a "Schnecke" (Swedish 'Snäcka'), and thus appears to have been a gastropod, possibly a *Murex*. If a lamellibranch it would have been referred to as a 'Muschel' (Swedish 'Mussla'). A scallop shell in German is a "Kammuschel" and in Swedish a "Kammussla." It should be in the power of the International Commission to declare a *nomen dubium* to be equivalent to a *nomen nudum* in special cases such as the present one. It would be absurd to scrap *Pecten* Müller on the grounds that *Pecten* Osbeck is a *nomen dubium*.

Dr. C. W. Stiles, Secretary of the International Commission on Rules of Nomenclature, very kindly gave the problem his consideration and is of the opinion that:

Osbeck's Pecten must be considered a *nomen nudum*. The translator of the German article quoted here took poetic license. A correct translation would read, "with the anchor rope a piece of coral was brought up upon which a red snail (Schnecke) was attached, which showed many branches on the shell." The word "Schnecke" might lead one to believe that you were dealing with a gastropod. The fact that he used the word shells (Schalen) indicates a bivalve. Red color is common to many mollusks, so you have nothing by means of which you could even approximately say what this thing might be.

To summarize: It appears that the later editions of Osbeck are not available, since the names are not "reinforced by adoption or acceptance," nor has the nomenclature been revised. It seems that, according to the rulings of the

International Commission, and according to the opinions of paleontologists quoted, *Pecten* Osbeck is a *nomen nudum*.

Locality.—World wide (fossil). Living in the warmer seas.

Horizon.—Cretaceous to Recent.

Subgenus PECTEN, s. s.

Diagnosis.—Shell equilateral, orbicular, inequivalve; the right valve always the more convex; the left usually flat, or even concave in the umbonal region. The left usually the smaller, so that it fits closely inside the scalloped margin of the right. Auricles moderately large, subequal; byssal sinus below the right anterior auricle very shallow; ctenolium usually absent; sculpture consists of radial ribs; sometimes with more or less well developed concentric, and secondary radial sculpture.

Pecten (Pecten) elixatus Conrad
Pl. 4, Figs. 1, 2.

Pecten elixatus Conrad, Acad. Nat. Sci. Phila., Proc., **2**: 174, 1844; Conrad, Acad. Nat. Sci. Phila., Jour., **1**: 130, pl. 14, figs. 13, 14, 1847; Heilprin, Acad. Nat. Sci. Phila., Proc., **33**: 417, 1881; Dall, Wag. Free Inst. Sci., Trans., **3**: 719, 1898, *partim*; Harris, Bull. Am. Pal., **8**:15, pl. 2, figs. 10, 11, 1919; Kellum, U. S. Geol. Surv. Prof. Paper **143**: 4, 1926.

Description.—Conrad's original description:

Suborbicular, inferior valve ventricose, with fourteen wide, elevated, rounded ribs, and with concentric wrinkles. Height 1¼ inches.

Only the syntypes of this species and a fragment collected by Harris are known. The right valve has fourteen well elevated, nearly flat-topped ribs, which, at the margins, are about the same width (2 mm.) as the rounded interspaces. Both ribs and interspaces become narrower at the submargins. Umbonal area and auricles deeply eroded. The somewhat widely spaced, elevated lamellae are reflected slightly toward the beak on the sides of the ribs and pass directly across the interspaces. Submargins lack radial sculpture, but are concentrically lamellated. Auricles doubtful. Valve ribbed internally. Left valve only slightly convex; it has 14 ribs which, at the margins, are about half the width of the interspaces. Ribs slightly more rounded than those of the right valve. Submargins narrow, steep, sculptured only by the concentric lamellae. Auricles small. Valve ribbed internally.

Remarks.—This species is certainly very closely related to *poulsoni*, and may finally be regarded as identical with it when sufficient material is available for study. Dall referred *elixatus* to *poulsoni*, while Harris regarded it as a distinct species, although a close relative of *poulsoni*.

Dimensions.—Syntypes: Right valve, height 32, width 33 mm.; left valve, height 27, width 28 mm. Convexity, right valve, 11 mm.

Localities.—Santee Canal, S. C. (type), Conrad; Trent River, about six miles below Polloksville, N. C., Harris.

Horizon.—Jackson (Eocene).

Syntypes.—Academy of Natural Sciences of Philadelphia, Cat. No. 12576.

Pecten (Pecten) poulsoni Morton

Pl. 1, Figs. 5, 6.

Pecten sp., LeSeur, Walnut Hills Foss.: pl. 5, figs. 3, 4, 1829.

Pecten poulsoni Morton, Syn. Org. Rem.: 59, pl. 19, fig. 2, 1834; Morton Acad. Nat. Sci. Phila., Jour. **1**:217, 1842; Conrad, Am. Jour. Sci., **2**:125, 210, 1846; Tuomey, Geol. Surv. Ala., 1st Bienn. Rept.: 154-55, 158, 1850; Hilgard, Rept. Agri. and Geol. Miss.: 140, 144-45, 1860; Conrad, Acad. Nat. Sci. Phila., Proc., **17**:184, 1865; Conrad, Am. Jour. Conch., **1**: 14, 1865; Hopkins, La. Geol. Surv. 2nd Ann. Rept.: 17, 1870; Heilprin, Acad. Nat. Sci. Phila., Proc., **32**: 366, 369, 1880; Heilprin, op. cit., **33**: 158, 417, 1881; Meyer, Am. Jour. Sci., (3), **29**: 467, 1885; Meyer, op. cit., **30**: 61, 63, 65, 68, 72, 1885; Hilgard, op. cit., **30**: 301, 1885; Aldrich, op. cit., **30**: 301, 1885; Langdon, op. cit., **31**: 203-6, 1886; Meyer, op. cit., **32**: 21, 1886; Morton, U. S. Geol. Surv., Bull., **43**: 233, 1887; Johnson, Am. Jour. Sci., (3), **36**: 233, 1888; Johnson, op. cit., **38**: 215, 1889; Foerste, op. cit., **48**: 44, 1894.

Pecten (Janira) promens de Gregorio, Ann. de Geol. et de Pal., **7** et **8** liv.: 181, pl. 21, figs. 17-25, 1890.

Pecten (Janira) poulsoni Morton, de Gregorio, Ann. de Geol. et Pal., **7** et **8** liv.: 182, pl. 21, fig. 27, 1890.

Pecten (Pecten) poulsoni Morton, Dall, Wag. Free. Inst. Sci., Trans., **3**: 719, 1898.

Description.—Morton's original description:

Suborbicular; superior valve flat; ribs fourteen, not profoundly elevated, with crowded wrinkled striae, inferior valve ventricose, with prominent rounded ribs, the intervals striated; ears sub-equal.

Shell suborbicular, rather thick, strongly sculptured. Sixteen to eighteen abruptly elevated ribs which are somewhat narrower than the interspaces. In adults the ribs take on from 1 to 3 longitudinal grooves near the margins. Infrequently such grooves continue to the umbonal areas. The sculpture of fine, wavy, concentric, sometimes scaly lamellae is usually much better developed on the left valve. It tends to become obsolete on the ribs of the right valve. Submargins narrow, faintly sculptured with fine, concentric lines which extend across the radial threads of the auricles. Auricles rather small, subequal. Byssal notch inconspicuous, ctenolium lacking. Interior fluted.

Remarks.—*Pecten poulsoni* is differentiated from *C. perplanus* by its fewer ribs, thicker, larger shell, absence of a ctenolium. The valves of *perplanus* are about equally inflated, while in *poulsoni* the left valve is nearly flat and the right is very convex. Young left valves are commonly flat, while adult valves are usually slightly convex in *poulsoni*. Ribs of the right valve of *P. elixatus* are broader, and have two sulci which appear about 7 or 9 mm. from the margin of the valve. The ribs of the left valve of *elixatus* are not keeled as they commonly are in *poulsoni*. They appear to be flat-topped and to show no traces of sulci on their summits. It may be that *elixatus* should properly be considered a variety of *poulsoni*. If only the left valve (syntype) were known it might be so considered. Lacking specimens other than the syntypes, it seems best for the present to retain the specific name of *elixatus*.

Dimensions of hypotypes.—Right valve, height 30, width 27 mm. Left valve, height 30, width 28 mm.

Localities.—St. Stephens, Ala. (type), Morton; Carson's Creek, Warren

County, Miss., Dall; Shubuta, Miss.; near Rosefield, La., Vaughan; Archer, Fla., Dall; Jarves Spring, Fla., Dall; Vicksburg, Miss. (fig. 5); Mint Springs Bayou, north of Vicksburg, Miss.; Byram, Miss. (fig. 6); Ocmulgee River 1½ miles below Hawkinsville, Ga.

Horizon.—Vicksburg (Oligocene).

Hypotypes.—Collections Cornell University.

Syntypes.—Academy of Natural Sciences of Philadelphia, No. 274.

Pecten (Pecten) biformis Conrad

Pl. 4, Figs. 5, 6.

Pecten biformis Conrad, Acad. Nat. Sci. Phila., Proc., **1**: 306, 1843; Conrad, Foss. Med. Tert.: 73, pl. 42, fig. 1, 1845; Conrad, Acad. Nat. Sci. Phila., Proc., **14**: 581, 1862; Heilprin, op. cit., **33**: 418, 1881.

Pecten (Pecten) biformis Conrad, Dall, Wag. Free Inst. Sci., Trans., **3**: 720, 1898.

Description.—Conrad's original description:

Inequivalved; superior valve flat; inferior ventricose; ribs five or six, on the umbo, large, convex, with minute, reticulated striae; from a concentric sulcus below the umbo, the ribs suddenly become less prominent, very wide and composed of fasciculi of smaller irregular ribs; ears equal, small.

The figured right valve (holotype) has only 5 simple, broadly rounded ribs which are about the same width as the interspaces. About 15 mm. from the beak these ribs begin to develop striations on their summits, and from 17 mm. to the margin of the valve the ribs are broken up into numerous riblets which are not of uniform size nor evenly rounded. Marginal riblets leading from each primary rib tend to be large, while 2 or 3 smaller ones occur in slightly depressed interspaces. Submargins narrow, steep, unornamented. Auricles small, with 5 or 6 reticulated radials. Marked byssal fasciole; ctenolium of 2 or 3 denticles. Internally, the shell reflects the sculpture of the disk. A left valve from the type locality (figured) has 6 primary ribs which show less marked tendency to break up into fascicles of riblets, probably because it is a younger shell. Depressed in umbonal region. Another left valve, height 17 mm., from the type locality shows a faint tendency for the ribs to break up into fasciculi of riblets. Auricles small, finely ribbed radially. Valves of this species are all translucent.

Dimensions.—Holotype, a right valve, height 26.5, width 24, convexity 8, hinge 10.5 mm. Left valve, height 20, width 17 mm.

Locality.—Pamunkey River, Va. (type), Conrad.

Horizon.—Miocene?

Holotype.—Academy of Natural Sciences of Philadelphia, Cat. No. 12580. Also hypotypes.

Pecten (Pecten) kathrinepalmerae Tucker

Pl. 2, Fig. 3.

Pecten kathrinepalmerae Tucker, Ind. Acad. Sci., Proc., **40**: 244, pl. 1, figs. 2, 5, 1931.

Description.—The original description:

Shell large, rather thin, quite gibbous, radially sculptured with little elevated, broad, rounded ribs which bifurcate and so increase in number. General surface of disk

concentrically sculptured with fine, scaly lamellae. In the type the concentric lamellae are practically worn away, except next to the margins. Sub-margins very narrow, ornamented only with fine concentric lines. Ribs become narrower near the sub-margins. Disk bent over abruptly at the margins. Anterior byssal ear rather large, radial sculpture feeble, fasciole distinctly marked. Byssal notch shallow, inconspicuous. Posterior ear? Interior fluted to beak. Ctenolium absent. Resilial pit rather broad, shallow. Cardinal margin of valve bent over the left. Auricular crura developed. Provinculum retained in the form of numerous, fine ridges normal to the hinge line.

Shell translucent. About 23 ribs which, in cross section, appear low and somewhat broad; a single one bifurcates to form two narrower ones, while a second one carries a deep sulcus. Concentric lamellae reflected away from the beak as they cross the radials. Internally lirate, reflecting the external radial sculpture.

Remarks.—Shell much thinner than that of *hemicyclicus;* ribs more numerous and less elevated.

Dimensions.—Holotype, height 72.5, width 72, convexity 23 mm.

Locality.—Baileys Ferry, Fla. (type).

Horizon.—Chipola (Miocene).

Holotype.—Collection of H. I. Tucker.

Pecten (Pecten) burnsi Dall
Pl. 4, Figs. 3, 4

Pecten (Pecten) burnsi Dall, Wag. Free Inst. Sci., Trans., **3**: 720, pl. 34, fig. 8, 1898; Gardner, U. S. Geol. Surv., Prof. Paper **142**-A: 44, pl. 12, fig. 1, 1926.

Description.—Dall's original description:

Shell resembling *P. poulsoni* Morton, but smaller, less inflated, and with larger ears; ribs 14, on the right valve strong, each divided by 2 grooves so as to be tricarinate, the minor keels scabrous, the interspaces narrower, with fine concentric sculpture; ears and submargins radially threaded, the ears large, subequal, the notch shallow; left valve flat, the ribs angular, simple, strong, with fine concentric sculpture; ears large, radially finely threaded; interior fluted.

Dall's figure indicates a more strongly developed beading on the summits of the ribs than occurs on any specimens from the type locality. Strong provinculum; slight byssal fasciole. Valves ribbed internally. A young left valve from the type locality, height 10 mm., is flat and shows similar radial threading on the auricles and on the submargins. The beaded sculpture on the summits of the ribs begins at this stage in the growth of the shell.

Remarks.—*P. poulsoni* has more numerous ribs than this species and lacks its characteristic beaded sculpture.

Dimensions.—Holotype, height 18, width 19, semi-diameter 6 mm.

Locality.—1 mile below Baileys Ferry, Fla. (type), Dall.

Horizon.—Chipola (Miocene).

Holotype.—U. S. National Museum, Cat. No. 114781.

Pecten (Pecten) humphreysi Conrad
Pl. 3, Fig. 3; Pl. 4, Fig. 10

Pecten humphreysi Conrad, Nat. Inst., Proc., Bull., **2**: 194, pl. 2, fig. 2, April-June, 1842; Meek, Miocene Check List, Smith. Misc. Coll., **1**: 4, 1863.

Vola humphreysi Conrad, Acad. Nat. Sci. Phila., Proc., **14**, 582, 1863; Whitfield, U. S. Geol. Surv., Mon. **24**: 32-34, pl. 4, figs. 6-9, 1894.

Pecten (Pecten) humphreysi Conrad, Dall, Wag. Free Inst. Sci., Trans., **3**: 720-21, 1898; Glenn, Md. Geol. Surv., Miocene: 372, pl. 98, figs. 10-12, 1904.

Description.—Conrad's original description:

Suborbicular, inferior valve convex; superior flat, and with about seven remote, narrow, convex ribs, and concentrically wrinkled; towards the apex is a concave depression; ears equal, sides direct and straight; inferior valve with the ribs wide, approximate, plano-convex and longitudinally striated; one of the ears emarginate at the base.

Right valve generally has 7 or 8 broad, concentrically striated ribs. Left valve flat, frequently concave in the umbonal region. Right more convex, sometimes strongly so. Auricles rather large, not oblique. Byssal notch inconspicuous. Interior of valve reflects external radial sculpture.

Remarks.—Comparison of specimens of *P. laqueatus* Sowerby from Japan with the Maryland *humphreysi* leaves no doubt that they are only generically related. There seems little basis for placing Sowerby's species in synonymy under *humphreysi,* as Grant and Gale, San Diego Soc. Nat. Hist. Mem., 1:221, 1931, have done.

Dimensions of hypotypes.—Right valve, height 40, width 36 mm.; left valve, height 28, width 27.5 mm.

Localities.—Mr. Wilkenson's Farm, Calvert County, Md. (type), Conrad; Centreville, Burch, Fair Haven, Lyon's Creek, Truman's Wharf, White's Landing, and Reeds, Md., Dall; Shiloh, and Jeicho, N. J., Dall; Chesapeake Beach, and Plum Point, Md.

Horizon.—Calvert (Miocene).

Hypotypes.—Collection of H. I. Tucker.

Syntypes.—Academy of Natural Sciences of Philadelphia.

Pecten (Pecten) humphreysi woolmani Heilprin

Pl. 4, Fig. 11

Pecten humphreysi var. *woolmani* Heilprin, Acad. Nat. Sci. Phila., Proc., **39**: 405, 1887; Dall, Wag. Free Inst. Sci., Trans., **3**: 721, 1898.

Description.—Heilprin's original description:

Under this name I propose to designate a *Pecten* which appears to be only a variety or sub-species of the Maryland *P. humphreysii,* differing from the normal type of that species in the greater elevation of the ears, and the more distinct quadrangulation of the ribs of the convex valve. The ribs are also more prominently lined. All the New Jersey specimens that I have seen of what appears to be *Pecten humphreysii* agree in these characters.

In the collections of the Academy of Natural Sciences of Philadelphia are plete left valve which is figured, since it was apparently identified by Heilprin. original description was apparently based upon fragments of a right valve. Lacking these specimens, it seems best to designate as neoholotype the incomplete left valve which is figured, since it was apparently identified by Heilprin.

About 30 mm. from the beak a median, rounded sulcus develops on the summits of the ribs which gives them the appearance of having a keel along each margin. Ribs less than one fourth the width of the interspaces. Elevated,

closely spaced lamellae pass directly across the ribs and interspaces. Concentrically lamellated auricles have obsolete radials.

Dimensions.—Neoholotype, a fragment of a left valve, height 42, width 50 mm.

Localities.—Well boring at Atlantic City, N. J. (type), Heilprin; Shepherd's Pit, Shiloh, N. J., Pilsbry and Harbison.

Horizon.—Miocene.

Neoholotype.—Academy of Natural Sciences of Philadelphia.

Pecten (Pecten) smithi Olsson

Pl. 1, Fig. 4.

Pecten (Pecten) smithi Olsson, Bull. Am. Pal., **5**: (24), 11, pl. 4, figs. 1, 2, 1914.

Description.—Olsson's original description:

Left valve small, thin, flat, with a slight depression at the beak; shape ovate, as high as broad; ribs about 20 to 22 in number, low and separate by flat interspaces, about twice as wide as the ribs; ribs becoming obsolete on the anterior submargin and probably also on the posterior, and are here replaced by a rather prominent ridge; ribs and interspaces at first crossed by concentric lamellose lines, which also pass over the submargins and on to the ears; these concentric lines are equally spaced and the lamellae appear to have been originally roof-like, passing from one line to the other; this concentric sculpture is developed for a time and then suddenly ceases, the remainder of the shell having only the ribs; interior of shell smooth, lirated by the ribs.

Remarks.—On the paratype, a left valve, the concentric lines cover the whole valve. This sculpture is absent from the basal portion of the holotype. Apparently the species loses this type of sculpture abruptly at this stage in its development.

Dimensions.—Holotype, height 26, width 29 mm.

Locality.—Kingsmill, Va. (type), Olsson.

Horizon.—Yorktown (Miocene).

Paratype.—Paleontological Research Institution.

Holotype.—Paleontological Research Institution.

Pecten (Pecten) macdonaldi Olsson

Pl. 3, Fig. 5.

Pecten macdonaldi Olsson, Bull. Am. Pal., **9**: 370, pl. 16, figs. 1, 2, 1922.

Pecten (Pecten) macdonaldi Olsson, Mansfield, Fla. Geol. Surv., Bull. **8**: 57, pl. 14, figs. 5, 6, 1932.

Description.—Olsson's original description:

Shell large, suborbicular; ears of medium size and equal; left valve is slightly convex due to the middle of the shell being transve-sely humped or vaulted and a depressed zone follows on the inner slope of each of the raised dorsal sub-margins; the right valve is slightly but evenly convex; sculpture of the right valve consists of about twenty-six, low ribs which widen out as they approach the ventral margins; their interspaces are at first nearly as wide as the ribs themselves but become only ½ to 1/3 as wide ventrally; the left valve has 21 or 22 narrow ribs and wider interspaces; on the dorsal sub-margins, the ribs are small and fade away; surface with fine, even, raised lines best seen on the left valve.

Remarks.—This species has much the same outline as *P. maximus* L. It is larger than *P. gatunensis* Toula. *Pecten ochlockoneensis* is more inflated and has the ribs of the left valve more widely separated.

Dimensions.—Holotype, height 98, width 83 mm.

Locality.—West of Gatun locks, C. Z. (type), Olsson; Red Bay, Fla., Mansfield; Vaughan Creek, Walton County, Fla., Mansfield and Ponton.

Horizon.—Choctawhatchee, Gatun (Miocene).

Holotype.—Paleontological Research Institution.

Pecten (Pecten) ochlockoneensis Mansfield

Pl. 1, Fig. 3.

Pecten (Pecten) ochlockoneensis Mansfield, Fla. Geol. Surv., Bull. 8: 56, pl. 13, figs. 1, 3, 1932.

Description.—Mansfield's original description:

Shell of moderate size, equilateral, sculptured with rather strong ribs. Right valve moderately convex and evenly rounding to submargins, with 22-23 moderately wide, nearly flat, dichotomous ribs separated by narrower interspaces, the three lateral ribs being a little weaker. Left valve with raised lateral margins, weakly depressed behind the umbo and nearly flat below, and with 16 slightly rounded non-dichotomous ribs with much wider interspaces. Ears on right valve subequal, large, the anterior marked with four radials and two on posterior ear. Surface of both valves covered with moderately coarse concentric lamellae.

Remarks.—*Pecten hemicyclicus* is larger than this species, and is wider in proportion to its height. The right valve is more inflated, the left less concave, and it lacks the radials on the auricles which are characteristic of *ochlockoneensis*. The ribs of *hemicyclicus* rarely increase by dichotomy as they do in this species. *P. kathrine palmerae* is more nearly semicircular in outline than *ochlockoneensis*, and the margin is bent under much more abruptly.

Dimensions.—Holotype, height 85, width 96, diameter, 15 mm.

Locality.—Rock Creek, Franklin County, Fla., Mansfield; Jackson Bluff, Leon County Fla, (type), Mansfield; Hamlin Pond, Washington County, Fla., Mansfield.

Horizon.—Choctawhatchee (Miocene).

Holotype.—U. S. National Museum, Cat. No. 371134.

Pecten ochlockoneensis violae subsp. nov.

Pl. 1, Figs. 1, 2.

Description.—Shell resembles *ochlockoneensis* in outline and shape of auricles. Right valve has 15 broad, low, slightly rounded ribs. About 35 mm. from the beak a sulcus appears on the summit of each rib and deepens as it approaches the margin. Anteriorly there are two much narrower, simple ribs, and posteriorly three. Ribs wider than the interspaces. Whole valve sculptured with somewhat widely spaced, concentric lamellae. Submargins have only concentric lamellae. Auricles subequal; anterior byssal auricle, 4 obscure

radials, posterior, 1; both closely lamellated. Interior broadly ribbed; auricular crura; provinculum. Left valve has 16 elevated, widely spaced, rounded ribs. Occasionally an intercostal. Valve concave in umbonal region. Disk and auricles have more dense, concentric lamellae than the right valve. An occasional rib shows a tendency to develop a sulcus. Radials on auricles obscure.

Remarks.—This subspecies is differentiated from *ochlockoneensis* by its fewer ribs, earlier and more marked tendency to develop sulci on the summits of the ribs, and more closely spaced concentric lamellae.

Dimensions of syntypes.—Probably a single individual. Right valve, height 91, width 92 mm.; left valve, height 88, width 90 mm.

Locality.—Jackson Bluff, Fla. (type).

Horizon.—Choctawhatchee (Miocene).

Syntypes.—Paleontological Research Institution.

Pecten (Pecten) leonensis Mansfield

Pl. 2, Figs. 1, 2; Pl. 4, Figs. 8, 9.

Pecten (Pecten) leonensis Mansfield, Fla. Geol. Surv., Bull. 8: 58, pl. 9, figs. 2, 3, 1932.

Description.—Mansfield's original description:

> Shell small, subovate, subequilateral, both valves strongly sculptured. Right valve strongly inflated; left valve nearly flat. Right valve sculptured with 10 or 11 sharp, triangular, primary ribs intercalated with an occasional secondary radial thread. Left valve with five primary and six secondary ribs, which are similar in outline to those of the opposite valve. The secondaries alternate in position with the primaries and are about half their size. Ears subequal and are ornamented with five moderately strong radials. The right anterior ear is strongly sinuate. The surface of the shell is concentrically sculptured with coarse scabrous lamellae. Within, the valves are strongly scalloped, reflecting the wide exterior intercostal spaces.

The ribs of the left valve are keeled, the interspaces flat. The concentric lamellae are reflected toward the beaks on the sides of the ribs, curved toward the ventral margin on the summits of the ribs, and are nearly perpendicular to the ribs in the interspaces. Under the microscope the valves show well developed cardinal crura, provinculum, and ctenolium.

Dimensions of syntypes.—Right valve, height 17, width 16; left valve, height 17, width 18 mm.; diameter 2 mm. Hypotypes: Fig. 8, height 12, width 11 mm., Ft. Denaud, Fla.; fig. 9, height 18, width 17 mm., Walkers Bluff, N. C.

Localities.—Jackson Bluff, Holland post office, near Clarksville, Fla. (type), Mansfield; Porters Landing, Savannah River, Ga., Mansfield; Ft. Denaud, and Acline, Fla.; Walkers, Bluff, N. C.

Horizon.—Choctawhatchee (Miocene), Waccamaw, and Caloosahatchie (Pliocene).

Hypotypes.—Collection of H. I. Tucker.

Syntypes.—U. S. National Museum, Cat. No. 371256.

Pecten (Pecten) wendelli Tucker

Pl. 4, Fig. 7.

Pecten (Pecten) wendelli Tucker, Am. Mid. Nat. **15**, (5): 612, pl. 25, fig. 1, 1934.

Description.—The original description:

Shell very thin, equilateral, suborbicular. A single strong radial cord extends nearly to the beak anteriorly and another posteriorly; three weaker, equally spaced cords lie between the secondary cords and become obsolete 2 mm. from the margin of the disk. Fine, concentric lines extend straight across the radials. Submargins plain, narrow, steep. Auricles large, probably subequal, with about 7 fine, scabrous radial threads. Internal margin of the shell grooved for about 2 mm. Provinculum; auricular crura.

Remarks.—This species differs strikingly from *P. leonensis* Mansfield in sculpture. The greater portion of the disk of *wendelli* has only concentric sculpture of fine lines while the whole disc of *leonensis* has strong radial sculpture. The concentric lamellae are reflected away from the beak on the summits of the ribs of *leonensis*, while on *wendelli* the lines pass directly across the radials. The concentric sculpture of *wendelli* is much weaker and the shell is more nearly orbicular.

Dimensions.—Holotype, height 14, width 13 mm.

Locality.—Ft. Denaud, Fla. (type).

Horizon.—Caloosahatchie (Pliocene).

Holotype.—Collection of H. I. Tucker.

Pecten (Pecten) raveneli Dall

Pl. 2, Fig. 4.

Pecten (Pecten) raveneli Dall, Wag. Free Inst. Sci., Trans., **3**: 721, pl. 29, fig. 10, 1898.

Description.—Dall's original description:

Shell of much the size and form of *P. medius* Lam., but with 21 or 22 strong ribs; dichotomous in the right valve but rounded and simple in the left, with 3 or 4 finer threads on the sub-margins; interspaces on the right valve smaller than the squarish ribs, on the left sub-equal; right valve with sub-equal ears, each with three or four strong, round riblets; notch shallow; ears of the left valve concave, 2 ribbed, with less pronounced sculpture; surface of both valves covered with close set, concentric, elevated lines; interior fluted, crura moderately developed.

Perhaps it would be more nearly accurate to describe the ribs of the holotype, a right valve, as sulcate, or having tripartite marking. Only one rib is really dichotomous, and on another the sulcus extends to the umbonal region. Sulci extend in from the ventral margin about 10 mm. Submargins very narrow; threaded with fine, obsolete radials. A left valve from the same locality has 21 ribs and no intercostals.

Dimensions.—Holotype, height 42, width 47, diameter 13 mm.

Localities.—Caloosahatchie beds, Monroe County, Fla. (type), Dall; dredged off Cape Fear River, N. C., Dall; Acline, Moore Haven, Buckingham, Prairie Creek, Port Mayaca, and LaBelle, Fla.

Horizon.—Caloosahatchie (Pliocene).

Holotype.—U. S. National Museum, Cat. No. 107750.

Pecten (Pecten) hemicyclicus Ravenel

Pl. 2, Fig. 5; Pl. 3, Fig. 1.

Pecten hemicyclicus Ravenel, Cat. Foss. and Recent Shells, 1834; Meek, Smith. Misc. Coll., **7**: 4, 1864; Heilprin, Acad. Nat. Sci., Proc., **33**: 421, 1881.

Janira hemicyclica Ravenel, Tuomey and Holmes, Pleioc. Foss. S.C.: 25, pl. 8, figs. 1-4, 1857.

Pecten (Pecten) hemicyclicus Ravenel, Dall, Wag. Free Inst. Sci., Trans., **3**: 721, 1898.

Description.—Tuomey and Holmes' description:

T. testa sub-semicirculari, depressa, concentrice striata, inæquivalvi; valva inferiore convexa; costis marginem versus sulcatis; valva superiore costis convexis, sub-inæqualibus.

Shell somewhat semi-circular, depressed, striated concentrically and closely; inequivalve, equilateral, lower valve convex, ribs, toward the pallial margin, turned up and sulcate; upper valve depressed, or flat convex towards the pallial margin, ribs convex; buccal ears depressed, lower one with a stout ridge.

Two valves of the same individual in the U. S. National Museum, Cat. No. 15467, identified by F. S. Holmes, have this label:

This is one of the only three perfect specimens that has ever been found of this fossil. It was named and described by Dr. Ravenel of this place, from odd valves. It is but lately that I was fortunate in finding them in juxtaposition.

Right valve very convex; radial sculpture of 17 flat-topped ribs which develop sulci on their summits near the ventral margin. Whole valve concentrically sculptured by elevated, widely spaced lamellae. Submargins and auricles sculptured only by the more closely spaced, elevated, concentric lamellae. Byssal flexure slight. Provinculum; auricular crura. Left valve has 17 ribs which become nearly obsolete in the concave umbonal area. Concentric sculpture similar to that of the right valve.

In the collections of the Academy of Natural Sciences of Philadelphia are two imperfect valves of this species which are very nearly identical with those in the U. S. National Museum. Dimensions: Right valve, height 57, width 65 mm.; left valve, height 56, width 64 mm.; hinge 28 mm. The label is marked "S. Car.".

Dimensions of neoholotype.—Right valve, height 95, width 115 mm.; left valve, height 95, width 112 mm; hinge 52 mm.; diameter 35 mm.

Localities.—Grove, Cooper River, S. C. (type?); Goose Creek at Smiths, S. C. (neoholotype), Ravenel, Tuomey and Holmes.

Horizon.—Waccamaw (Pliocene).

Neoholotype.—Right and left valves of the same individual, deposited in U .S. National Museum, Cat. No. 15467.

Pecten (Pecten) brouweri Tucker

Pl. 3, Figs. 2, 4.

Pecten (Pecten) brouweri Tucker, Am. Mid. Nat., **15**: (5): 612, pl. 25, figs. 4, 5, 1934.

Description.—The original description:

Shell equilateral, very inequivalved, the right valve strongly convex; well developed

radial sculpture. On the right valve 14 broad, flat-topped primary and two secondary ribs at each submargin. Each primary rib has a cord on the summit, extending from the umbonal region to the margin of the disk. Fine, concentric, crowded imbrications on disk tend to become coarser and more conspicuous in the umbonal region. Interspaces flat, about half as wide as the primary ribs. Margins scalloped. Sub-margins narrow, steep, without ornamentation. Auricles nearly equal; five to six radials, which become obsolete near the beak. Left valve very slightly concave; 13 high, rounded ribs which develop a median sulcus about 14 mm. from the ventral margin of the disk. A single intercostal between two of the ribs on the anterior portion of the disk. Near the beak the ribs tend to become nearly obsolete. Fine, closely spaced, concentric sculpture over the disk and auricles. No radials on the submargins. Ribs about half as wide as the flat interspaces. One radial on each of the subequal auricles.

Remarks.—This species differs from *P. raveneli* Dall in width of interspaces, convexity, and number of ribs. The interspaces of *raveneli* are scarcely more than sulci; commonly has 22 ribs; much stronger, uniform, and coarser concentric sculpture than *brouweri;* the left valve of *raveneli* is more concave than that of this species.

Dimensions.—Syntypes: Right valve, height 43, width 46 mm.; left valve, height 41.5, width 45 mm.; diameter 21 mm.

Localities.—Walkers Bluff, N. C. (type); Nixon's Landing, N. C.

Horizon.—Waccamaw (Pliocene).

Paratypes.—Paleontological Research Institution.

Syntypes.—Collection of H. I. Tucker. Right and left valves of the same individual.

Pecten? anisopleura Conrad

Pecten anisopleura Conrad, in Kerr, Geol. Surv. N. Car., Appendix A: 18, 1875; Heilprin, Acad. Nat. Sci. Phila., Proc., **33**: 416, 1881; Dall, Wag. Free Inst. Sci., Trans., **3**: 740, 761, 1898.

Description.—Conrad's original description:

Shell ovate, ventricose, ribs about twenty-five, very unequal, crossed by arched squamose lines. Length 3 inches; height 3¼ inches.

In the intervals of the larger ribs there are two smaller ribs in some, one in others. Found by Dr. Yarrow 40 miles from Beaufort, North Carolina.

The shell is heavy, ovate, badly worn. Widely spaced, coarse, concentric lamellae are reflected toward the beak on the summits of the ribs, pass directly across the interspaces or are only slightly reflected toward the ventral margin. Probably on less worn valves the lamellae formed roof-like, erect scales. Submargins probably narrow, steep, plain. Auricles large, squarish. Ornamentation? Very little of the hinge is exposed, but there seems no doubt that this shell had better be referred to *Spondylus,* or perhaps to *Hinnites.* Dall concluded, after studying the holotype, that it was not a *Pecten.*

Dimensions.—Height 85, width 70 mm. (holotype).

Locality.—40 miles south of Beaufort, N. C. (type), Conrad.

Horizon.—Uncertain.

Holotype.—Academy of Natural Sciences of Philadelphia.

PLATE 1

FIGURES

1. *Pecten (Pecten) ochlockoneensis violae*, subsp. nov. Jackson Bluff, Leon County, Fla. (Choctawhatchee). Holotype.
2. *Pecten (Pecten) ochlockoneensis violae*, subsp. nov. Holotype.
3. *Pecten (Pecten) ochlockoneensis* Mansfield. Jackson Bluff, Leon County, Fla. (Choctawhatchee). Holotype.
4. *Pecten (Pecten) smithi* Olsson. Kingsmill, Va. (Yorktown). Holotype.
5. *Pecten (Pecten) poulsoni* Morton. Vicksburg, Miss. (Vicksburg). Hypotype.
6. *Pecten (Pecten) poulsoni* Morton. Byram, Miss. (Vicksburg). Hypotype.

(All figures x 0.6)

PLATE 2

FIGURES

1, 2. *Pecten (Pecten) leonensis* Mansfield. Jackson Bluff, Fla. (Choctawhatchee). Syntypes.
3. *Pecten (Pecten) kathrinepalmerae* Tucker. Bailey's Ferry, Fla. (Chipola). Holotype.
4. *Pecten (Pecten) raveneli* Dall. Monroe County, Fla. (Caloosahatchie). Holotype.
5. *Pecten (Pecten) hemicyclicus* Ravenel. Goose Creek at Smiths, S.C. (Waccamaw). Neoholotype

(All figures x 0.6)

PLATE 3

FIGURES

1. *Pecten (Pecten) hemicyclicus* Ravenel. Goose Creek at Smiths, S.C. (Waccamaw). Neoholotype.
2. *Pecten (Pecten) brouweri* Tucker. Walker's Bluff, N. C. (Waccamaw). Holotype.
3. *Pecten (Pecten) humphreysi* Conrad. Chesapeake Beach, Md. (Calvert). Hypotype.
4. *Pecten (Pecten) brouweri* Tucker. Holotype.
5. *Pecten (Pecten) macdonaldi* Olsson. West of the Gatun Locks, C. Z. (Gatun). Holotype.

(All figures x 0.6.)

PLATE 4

FIGURES

1, 2. *Pecten (Pecten) elixatus* Conrad. Santee Canal, S. C. Syntypes.
3. *Pecten (Pecten) burnsi* Dall. After Dall. Holotype.
4. *Pecten (Pecten) burnsi* Dall. Bailey's Ferry, Fla. (Chipola). Holotype.
5. *Pecten (Pecten) biformis* Conrad. Pamunkey River, Va. Hypotype.
6. *Pecten (Pecten) biformis* Conrad. Pamunkey River, Va. Holotype.
7. *Pecten (Pecten) wendelli* Tucker. Ft. Denaud, Fla. (Caloosahatchie). Holotype.
8. *Pecten (Pecten) leonensis* Mansfield. Ft. Denaud, Fla. (Caloosahatchie). Hypotype.
9. *Pecten (Pecten) leonensis* Mansfield. Walker's Bluff, N. C. (Waccamaw). Hypotype.
10. *Pecten (Pecten) humphreysi* Conrad. Plum Point, Md. (Calvert). Hypotype.
11. *Pecten (Pecten) humphreysi woolmani* Heilprin. Atlantic City, N. J. Neoholotype.

(All figures x 0.6.)

PLATE 1

PLATE 2

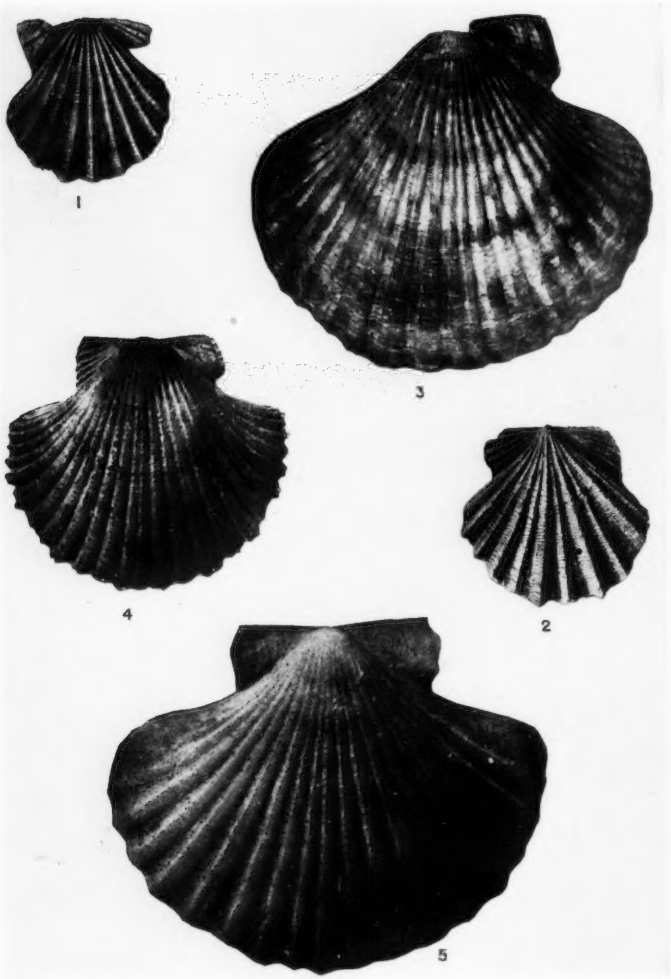
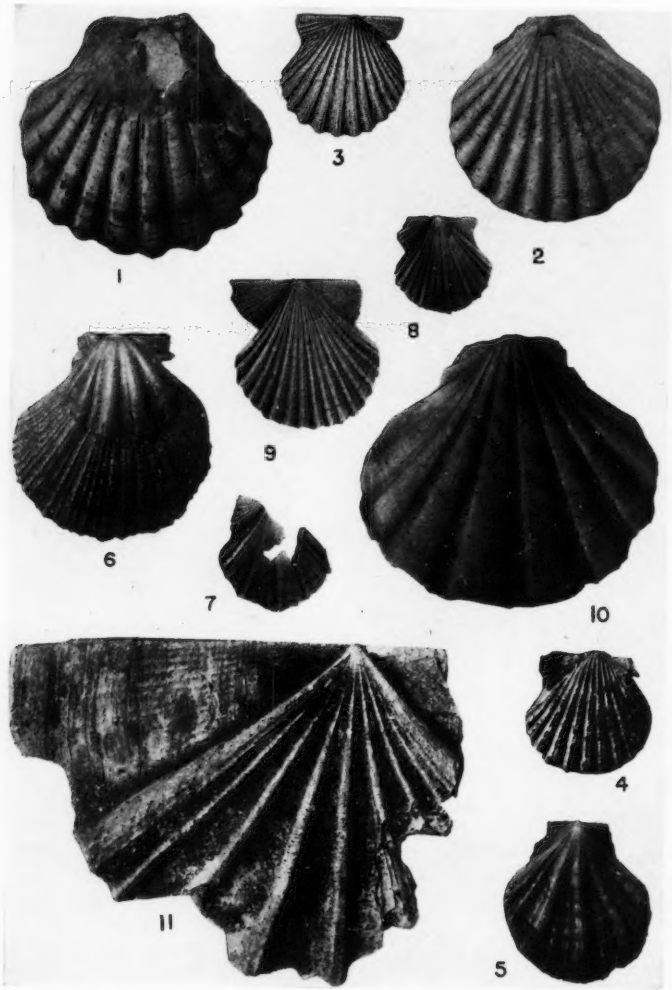


PLATE 3

PLATE 4



Fresh-water Ostracoda from Florida and North Carolina

Norma C. Furtos

Introduction

The fresh-water Ostracoda discussed in this report are, with one exception, based upon specimens obtained from the collections of algae taken from various wayside pools, ditches, rivers, and lakes of Florida during August of 1932 by R. Kenneth Salisbury of Terrace Park, Ohio. These specimens prove to be of especial interest in that they furnish an introduction to the fresh-water fauna of a region noted for its wide diversity and richness of plant and animal life. The excepted species, *Cypretta turgida* (Sars), from Beaufort, North Carolina, represents a first record for the western hemisphere.

Eighteen species and one variety are described from Florida; eleven, including the variety, are new. Two of the species are found also in northeastern and central United States, one in Yucatan, one in South America, one in Europe, and one in Russia. This is certainly far from a complete list of species occurring in Florida, being based upon twenty-seven samples representative of the August fauna only. We may point out, however, that the number and diversity of species taken indicates a luxuriant condition not characteristic of the summer fauna of more northerly regions such as Ohio or Massachusetts.

The author is deeply obliged to Mr. Salisbury through whose kindness in collecting and preserving the material this study was made possible, to Dr. J. Paul Visscher and the Graduate School of Western Reserve University for the use of microscopes and other equipment, and to Dr. M. H. Jacobs for library facilities of the Marine Biological Laboratory at Woods Hole, Massachusetts.

Systematic Discussion

Family *Cypridae*

Genus *Cypridopsis* Brady, 1867

The genus is ordinarily divided into two subgenera depending upon convexity of the valves, subgenus *Cypridopsis* including the tumid species and the subgenus *Potamocypris* most of the compressed forms. The following species, both distinctly tumid, are thus referred to subgenus *Cypridopsis*. Natatory setae of second antennae ordinarily well developed, distal segment of maxillary palp cylindrical, the two maxillary spines either smooth or toothed, claw of scratch-foot stout, caudal ramus rudimentary, ending in a simple flagellum.

Cypridopsis vidua vidua (O. F. Müller, 1776)

Cypris vidua, O. F. Müller, Zool. Dan. Prodr., p. 199, 1776.
Cypridopsis vidua, Brady, Intell. Observ., vol. 12, p. 117, 1867.
Pionocypris vidua, Sars, Crust. Norway, vol. 9, p. 135, t. 63, Bergen Mus. Pub., 1925.

Remarks.—This well known species is readily recognized by the small size (0.6 to 0.75 mm. in length), tumid shape when viewed from above, pitted hairy valves characterized by three brilliant dark-green or brown dorso-lateral bands on yellowish-green background. Despite its wide distribution, a male has never been reported.

Occurrence.—Very common in Florida.

Distribution.—North America, Europe, Siberia, China, South America, Azores.

Cypridopsis okeechobei sp. nov.

Fig. 1

Specific characters.—Female: from the side: Reniform, height very slightly less than two-thirds of length, left valve highest just in front of middle, right valve highest slightly behind middle; dorsal margin moderately arched, apex of right valve distinctly angled, that of left bluntly rounded; extremities broad, the anterior broader; ventral margin slightly sinuated; submarginal line removed from anterior and antero-ventral margin of each valve, the pore-canals much shorter on right valve than on left; pore-canals not extending to surface of margin, but terminate within, where each gives rise to a delicate marginal hair. From above: Moderately tumid, greatest breadth two-thirds of length occurring somewhat behind middle; sides very smoothly and evenly curved; left valve enclosing the right but hardly longer; anterior extremity narrowly rounded, the posterior broader. Surface of valves pitted, covered with short, curved hairs. Color light-yellow with dark-green stripes arranged in three dorso-lateral bands similar to *C. vidua vidua.* Length 0.64, height 0.40, breadth 0.42 mm. Natatory setae of second antenna extend beyond tips of terminal claws by about one-half length of claws. Masticatory process of maxilla with two smooth spines; distal segment of maxillary palp cylindrical, two and one-half times longer than wide. Branchial plate of first thoracic leg with at least three setae (exact number not determined). Terminal claw of scratch-foot rather stout, slightly curved, delicately pectinated, two-fifths length of penultimate segment. Caudal ramus with stout base clearly distinct from slender flagellum, the latter rather straight, one and one-half times longer than base, dorsal seta one-sixth length of flagellum.

Male: common, smaller than female, otherwise similar. Length 0.58, height 0.37 mm. Prehensile palps unequal, the larger palp with propodus fairly straight, length slightly less than three times width, dactylus moderately inflated, curved, almost as long as propodus; the smaller palp with propodus more slender, dactylus shorter, narrower, somewhat hook-like. Ejaculatory duct with fourteen closely approximately crowns of thick spines. Lateral lobe of penis bifurcate, projecting beyond apex of body.

Remarks.—This species may very readily be mistaken for *C. vidua vidua,* by virtue of the pitted, hairy nature of the valves, presence of conspicuous dorso-lateral bands and similar size. *C. vidua vidua,* however, is more tumid when viewed from above, natatory setae of second antenna extend only slightly beyond the terminal claws, claw of scratch-foot is smaller and male unknown.

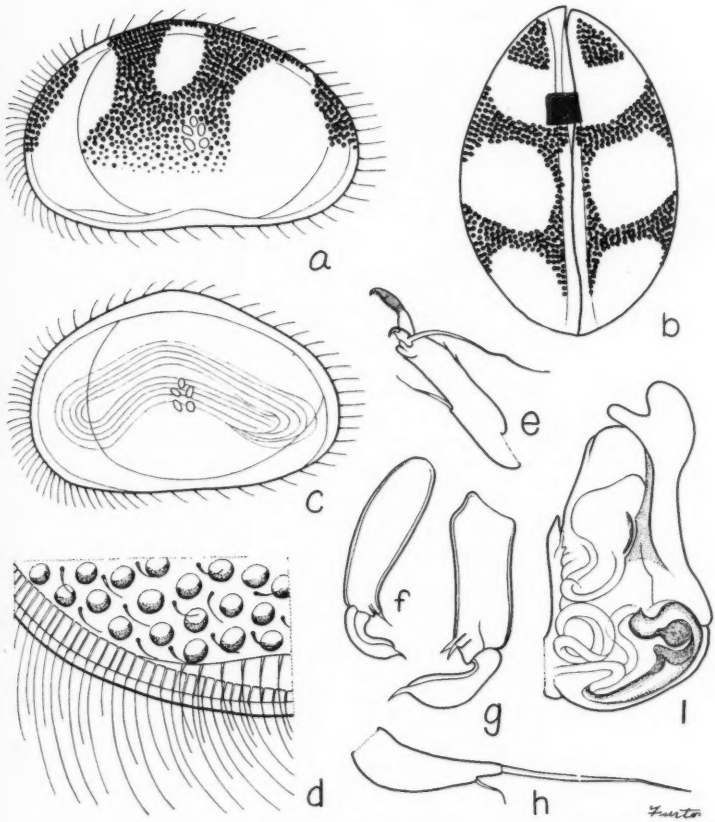


Fig. 1. *Cypridopsis okeechobei* new species: *a*, left valve of adult female; *b*, adult female, viewed from above; *c*, left valve of adult male; *d*, antero-ventral margin of left valve; *e*, distal portion of scratch-foot, female; *f-g*, prehensile palps; *h*, caudal ramus, female; *i*, penis.

Occurrence.—Type locality, Lake Okeechobee (two miles north of Canal Point, Aug. 28); north tributary of Caloosahatchee River at Labelle (Aug. 10). Holotype, U. S. Nat. Mus. No. 71375. Male paratype, U. S. Nat. Mus. No. 71376.

Genus *Cypretta* Vavra, 1895

Members of this interesting genus are small, never more than 1 mm. long, boldly arched when viewed from the side and tumid when viewed from above. Anterior margin of each valve with a row of radiating septa. Natatory setae

of second antenna usually well developed. Maxillary spines two in number, smooth or toothed. Terminal claw of scratch-foot stout. Caudal rami underdeveloped, quite slender, terminating in two seta-like claws, dorsal and terminal setae may be absent. Gonad (ovary or testis) coiled spiral-fashion in posterior valve-chamber.

Until quite recently this genus was considered to include only parthenogenetic species. The first male form recognized as a true *Cypretta* and so described by the author (1934) as *Cypretta brevisaepta,* is one of the commonest species of fresh-water Ostracod in Florida. Two other species have, however, been previously described for Peru, but erroneously referred by the authors to the genus *Eucypris*. The spiral character of the testis in the posterior valve-chamber, together with other typical *Cypretta* characters, indicate that these two forms, *Eucypris comites-roseni* Brehm (1924) and *Eucypris godeti* Delachaux (1928) are very closely related to the various sexually reproducing *Cypretta* species of Florida.

G. W. Müller (1912) gives a summary of species known to that date, listing eleven species, ten of which should be retained in the genus. Furtos (1934) listed fourteen species, while subsequent investigation and review of literature brings the list to twenty-one. Ten of this number have been reported in various parts of North and South America, and of these, four are very characteristic of the Florida-fauna, and a fifth quite common at Beaufort, North Carolina. Since so few collections have yielded such a surprisingly great number of species, additional work in the south-eastern part of North America will undoubtedly reveal many more. For this reason, a resumé of all know species of *Cypretta* is included in the form of a key. It is regrettable that some of these forms reported and accepted as definite species are too briefly described and inaccurately figured to be of much help in devising a key of this type. However, an attempt has been made to include these species.

Key to the known species of *Cypretta*

1. Terminal set of caudal ramus absent ---------- 2
   Terminal seta of caudal ramus present ---------- 10
2. Dorsal seta of caudal ramus absent ---------- 3
   Dorsal seta of caudal ramus present ---------- 4
3. Subterminal claw of caudal ramus absent ---------- *oxyuris* Daday
   Subterminal claw of caudal ramus present ---------- *sarsi* Brady
4. Dorsal seta of caudal ramus at least one-half length of subterminal claw ---------- *raciborskii* (Grochmaliki)
   Dorsal seta of caudal ramus very short ---------- 5
5. Length of valves at least 0.75 mm. ---------- 6
   Length of valves distinctly less than 0.75 mm. ---------- 8
6. Length of valves greater than 0.9 mm. ---------- *viridis* (Thompson)
   Length of valves less than 0.9 mm. ---------- 7
7. Terminal claw of scratch-foot geniculate ---------- *turgida* (Sars)
   Terminal claw of scratch-foot gently curved ---------- *papuana* Vavra
8. Breadth of valves equal to height ---------- *costata* Müller
   Breadth of valves greater than height ---------- 9

9. Maxillary spines smooth ---------- *tenuicauda* Vavra
   Maxillary spines toothed ---------- *nukuhivana* Furtos
10. Posterior margin of left valve tuberculated ---------- *globulus* (Sars)
    Posterior margin of left valve smooth ---------- 11
11. Natatory setae of second antenna rudimentary ---------- *godeti* (Delachaux)
    Natatory setae of second antenna well developed ---------- 12
12. Length of valves greater than 0.8 mm. ---------- 13
    Length of valves less than 0.8 mm. ---------- 19
13. Dorsal seta of caudal ramus at least one-half length of subterminal claw ---------- 14
    Dorsal seta of caudal ramus very much shorter ---------- 17
14. Maxillary spines toothed ---------- *comites-roseni* (Brehm)
    Maxillary spines smooth ---------- 15
15. Valves rather uniformly dark pigmented ---------- *nigra* n. sp. Furtos
    Valves not uniformly pigmented ---------- 16
16. Each valve with one longitudinal dark band ---------- *bilicis* n. sp. Furtos
    Valves spotted ---------- *brevisaepta* Furtos
17. Dorsal seta of caudal ramus removed from subterminal claw by 3 times width of ramus ---------- *remota* (Vavra)
    Dorsal seta of caudal ramus clearly closer to subterminal claw ---------- 18
18. Height of valves distinctly greater than breadth ---------- *minna* (King)
    Height of valves equal to breadth or slightly less ---------- *hirsuta* Henry
19. Maxillary spines smooth ---------- *intonsa* n. sp. Furtos
    Maxillary spines toothed ---------- 20
20. Length of valves not exceeding 0.6 mm. ---------- *dubiosa* (Daday)
    Length of valves greater than 0.6 mm. ---------- *seurati* Gauthier

Cypretta brevisaepta brevisaepta Furtos, 1934

Fig. 2, c-e

Cypretta brevisaepta, Furtos, Bernice P. Bishop Mus. Bull. 114, pp. 283-284, fig. 2, 1934.

Specific characters.—Female: from the side: Boldly arched, height greater than two-thirds of length, highest in middle; extremities broadly rounded, the anterior somewhat broader; ventral margin of left valve approximately straight, that of right slightly sinuated; nine to thirteen short inconspicuous, radiating septa and a narrow hyaline border along anterior margin of each valve. From above: Broadly ovoid, breadth exceeding the height, broadest in middle; left valve enclosing the right, projecting slightly beyond the right at the somewhat pointed anterior extremity, posterior extremity broadly rounded. Surface of valves smooth, with numerous short blunt spine-like processes, each bearing a strong curved hair. Color light-yellow with scattered dark-blue patches suggestive of dorso-lateral bands. Length 0.85, height 0.67, breadth 0.70 mm. Natatory setae of second antenna extend to tips of terminal claws or slightly beyond. Maxillary spines smooth; distal segment of maxillary palp two times longer than broad, very slightly narrowed distally. Terminal claws of scratch-foot geniculate, denticulate, slightly less than one-half length of penultimate segment. Caudal ramus gently curved, slender, somewhat broadened distally, fifteen times longer than width at level of dorsal seta, dorsal margin smooth; dorsal seta about one-half length of subterminal claw, the latter slender,

curved, seta-like, exceeding one-half length of terminal claw; terminal claw strong, gently curved, three-fourths length of ramus; terminal seta one-fifth length of terminal claw.

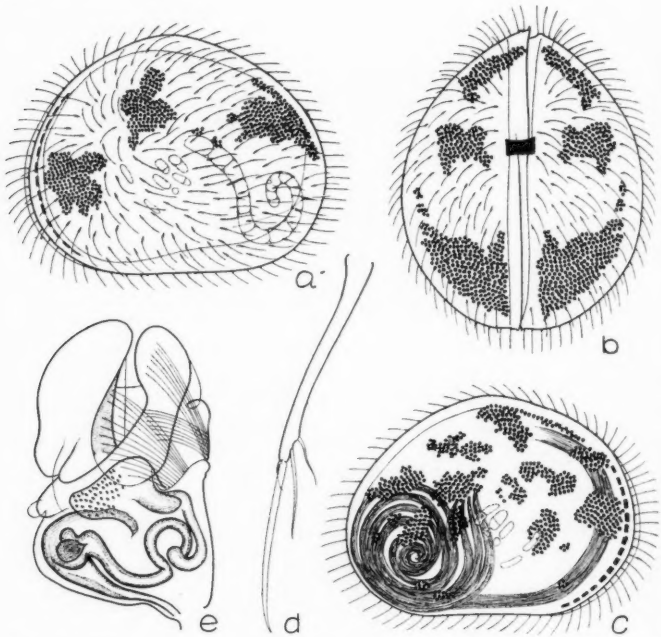


Fig. 2. *Cypretta brevisaepta* variety *sarta* new variety: *a*, left valve, adult female; *b*, adult female, viewed from above. *Cypretta brevisaepta brevisaepta* Furtos: *c*, right valve, adult male (surface hairs omitted); *d*, caudal ramus, female; *e*, penis.

Male: smaller than female, otherwise similar. Length 0.82, height 0.60, breadth 0.67 mm. Testis coiled in posterior valve-chamber. Prehensile palps slender, unequal; propodus of larger palp cylindrical, three and one-half times longer than narrowest width, dactylus stout, length equal to that of propodus, outer margin moderately inflated; propodus of smaller palp more elongated, dactylus short, hook-like. Ejaculatory duct barrel-shaped, armed with closely approximated slender spines roughly suggestive of eighteen crowns. Penis with two terminal lobes and a smaller median lobe armed with short, inconspicuous spine-like processes.

Occurrence.—Very common in wayside pools. Type locality, Buckingham (Aug. 10). Holotype, U. S. Nat. Mus. No. 68157. Male paratype, U. S. Nat. Mus. No. 68159.

Cypretta brevisaepta var. **sarta** var. nov.

Fig. 2, a-b.

Character of the variety.—Female: differs from *C. brevisaepta brevisaepta* in character of valve-pigmentation, which occurs as three large lateral patches on each valve, one patch near anterior extremity, another just behind the ocular region and a third near the posterior extremity. In other respects the two varieties are quite similar.

Male: with pigmentation similar to female. Copulatory appendages correspond to those of *C. brevisaepta brevisaepta.*

Occurrence.—Three miles north of Fort Meyers (flowing roadside-ditch, Aug. 17). Holotype, U. S. Nat. Mus. No. 71395.

Cypretta bilicis sp. nov.

Fig. 3.

Specific characters.—Female: from the side: Boldly arched, dorsal margin forming a blunt angle at apex, height about seven-ninths of length, highest somewhat in front of middle, extremities broadly and equally rounded; ventral margin straight, anterior margin of each valve with nine to twelve short, indistinct radiating canals; hyaline borders not evident. From above: Broadly ovoid, breadth slightly exceeding height, broadest in middle, left valve slightly longer than right, anteriorly extremity pointed, posterior broadly rounded. Surface of valves smooth, covered with slender hairs of moderate length. Color light-yellow with a very conspicuous dark longitudinal band on each valve, this band quite broad, extending in undulating fashion from mid-lateral region of anterior margin to dorsal half of posterior margin. Length 0.94, height 0.70, breadth 0.72 mm. Natatory setae of second antenna extend slightly beyond tips of terminal claws. Maxillary spines smooth; terminal segment of maxillary palp elongated, length slightly exceeding twice width of base, narrowed distally. Penultimate segment of second thoracic leg with seta extending as far as proximal ninth of terminal claw. Terminal claw of scratch-foot elongated, about one-half length of penultimate segment, curved, distal half delicately pectinated. Caudal ramus very slightly curved, eighteen times longer than width at dorsal seta, dorsal margin smooth; dorsal seta approximately one-half length of seta-like, irregularly curved subterminal claw, removed from claw by one-half width of ramus; terminal claw gently curved, three-fourths length of ramus; terminal seta short, stout, about one-seventh length of terminal claw.

Male: smaller than female, otherwise similar. Length 0.84, height 0.64 mm. Testis forms a conspicuous coil in posterior valve-chamber. Prehensile palps with elongated propodi rather similar; propodus of larger palp about three times longer than greatest width, dactylus three-fourths length of propodus, inflated along outer margin to form a right angle; propodus of smaller palp more slender, shorter, dactylus much narrower. Ejaculatory duct rectangular, with closely approximated spines irregularly arranged as sixteen crowns. Penis

roughly quadrangular, with two large terminal lobes and a small lateral lobe, the latter not bearing spinous processes.

Occurrence.—Type locality, four miles from Miakka toward Fruitville (roadside pool, Aug. 17). A few specimens were taken. Holotype, U. S. Nat. Mus. No. 71377. Male paratype, U. S. Nat. Mus. No. 71378.

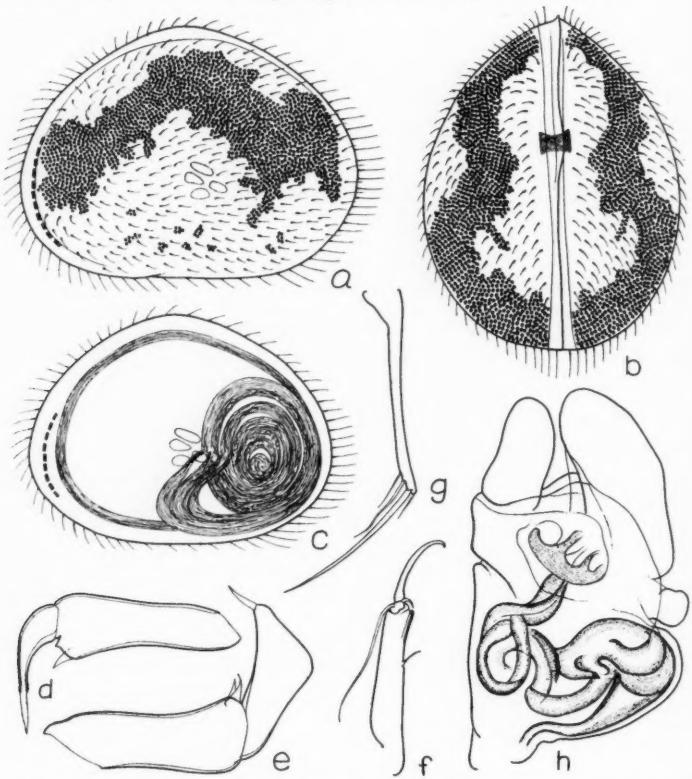


Fig. 3. *Cypretta bilicis* new species: *a*, left valve, adult female; *b*, adult female, viewed from above; *c*, left valve, adult male; *d-e*, prehensile palps; *f*, distal portion of scratch-foot, male; *g*, caudal ramus, male; *h*, penis.

Cypretta nigra sp. nov.

Fig. 4.

Specific characters.—Female: from the side: Boldly arched, height about seven-ninths of length, highest in middle, apex rounded, extremities broadly

and rather evenly rounded, ventral margin straight, anterior margin of each valve with from thirteen to sixteen very short radiating septa, those of the left valve hardly evident. From above: Broadly ovoid, breadth four-fifths of length, broadest slightly behind middle; left valve enclosing right, anterior margin somewhat pointed, posterior broadly rounded. Surface of valves smooth, covered with slender curved hairs; margins quite hairy, without a hyaline border; color dark-blue, the pigment extending over all of surface except marginal areas and ocular region. Length 0.92, height 0.70, breadth 0.76 mm. Natatory setae of second antenna extend to tips of terminal claws or slightly beyond. Maxillary spines smooth; distal segment of maxillary palp

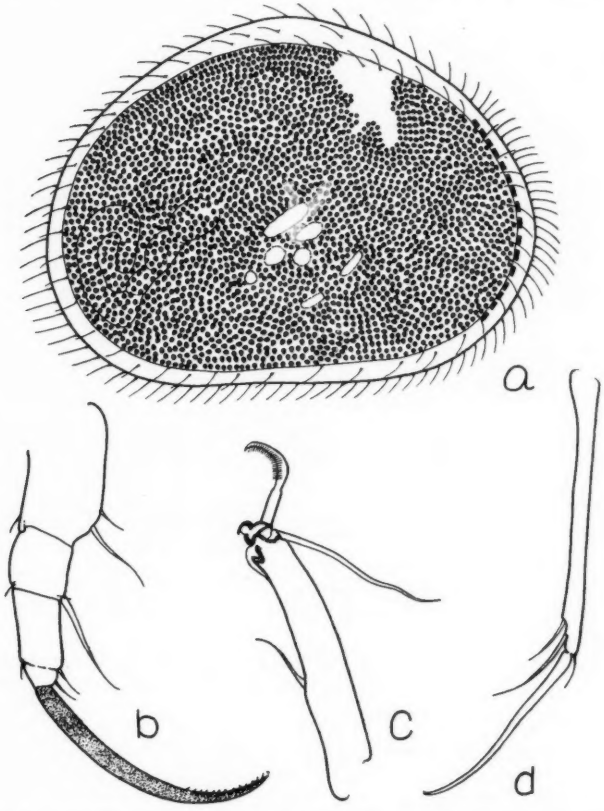


Fig. 4. *Cypretta nigra* new species: *a*, right valve, adult female; *b*, second thoracic leg; *c*, distal portion of scratch-foot; *d*, caudal ramus.

elongated, three times longer than width at base, narrowed distally. Terminal claw of second thoracic leg strong, of striking brown color and with delicate comb of denticles near tip; antepenultimate segment with seta extending only slightly beyond terminal segment. Terminal claw of scratch-foot long, one-third length of penultimate segment, distal half curved, pectinate. Caudal ramus slender, straight, sixteen times longer than width at dorsal seta, dorsal margin smooth; dorsal seta one-half length of seta-like subterminal claw, removed from claw by width of ramus; terminal claw weakly S-shaped, two-thirds length of ramus; terminal seta one-sixth length of terminal claw.

Male: not taken as yet but presence of sperm coils in female indicate existence.

Occurrence.—Type locality, four miles from Miakka toward Fruitville (wayside pool, Aug. 17). One female taken. Holotype, U. S. Nat. Mus. No. 71379.

Cypretta intonsa sp. nov.

Fig. 5.

Specific characters.—Female: from the side: Boldly arched, exceptionally hairy, height about two-thirds of length, highest in middle with a distinct apical angle more pronounced in right valve than in left; extremities broadly rounded, the anterior somewhat broader; ventral margin sinuated; valves quite similar, each with definite anterior and narrower posterior hyaline borders and anterior margin with about fifteen slender, dark radiating septa. From above: Broadly ovoid, breadth equal to height, broadest in middle; right valve enclosing left, extending slightly beyond left at each extremity; extremities rounded, the anterior narrower. Surface of valves delicately pitted, covered with numerous long, slender hairs and short stiff spines. Color light with four dark spots, one situated on antero- and another on postero-lateral surface of each valve. Length 0.55, height 0.40, breadth 0.40 mm. Natatory setae of second antenna extend slightly beyond tips of terminal claws. Maxillary spines smooth; distal segment of maxillary palp cylindrical, three times longer than wide. Antepenultimate segment of second thoracic leg with long seta extending as far as proximal third of brown terminal claw. Terminal claw of scratch-foot delicate, one-third length of penultimate segment, bent at tip, weakly pectinate. Caudal ramus sixteen times longer than narrowest width, dorsal margin smooth; dorsal seta almost as long as seta-like subterminal claw, removed from claw by less than width of ramus; terminal claw gently curved, three-fourths length of ramus; terminal seta very short, not more than one-tenth length of terminal claw.

Male: unknown.

Occurrence.—Type locality, two miles west of Kissimmee River (very common in clear flowing wayside ditch, Aug. 21). Vicinity of Childs (wayside pool. Aug. 9); six miles from Riverview (Little Bullfrog Creek, Aug. 16); twelve miles west of Okeechobee (wayside pool, Aug. 21). Holotype, U. S. Nat. Mus. No. 71380. Paratype, U. S. Nat. Mus. No. 71381.

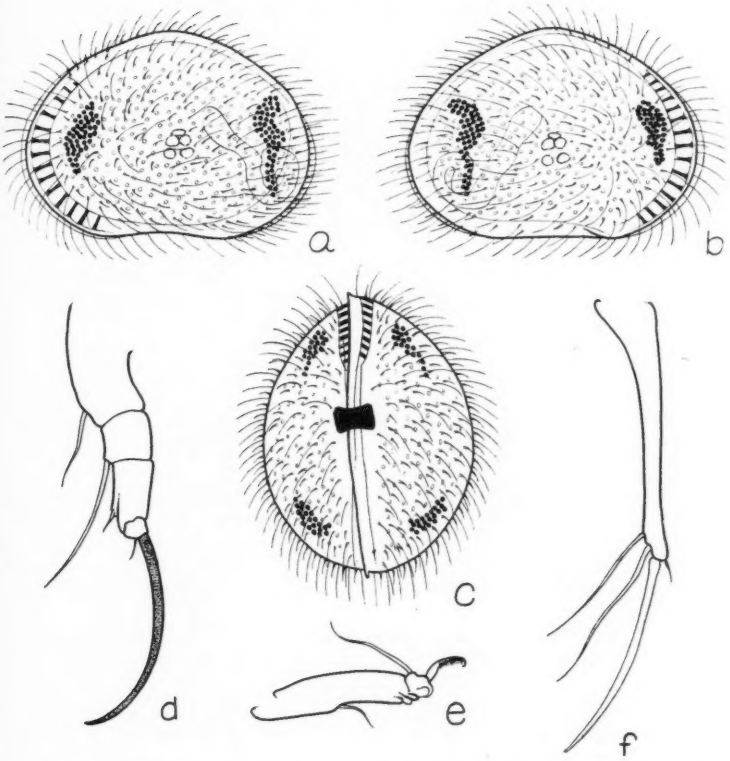


Fig. 5. *Cypretta intonsa* new species: *a*, left valve, adult female; *b*, right valve; *c*, adult female, viewed from above; *d*, second thoracic leg; *e*, distal portion of scratch-foot; *f*, caudal ramus.

Cypretta turgida (Sars, 1895)

Fig. 6.

Cypridopsis minna, Sars, Skr. Vidensk. Christiana, 1894, no. 5, p. 30, t. 4, figs. 3 a-c, d, 1894.

Cypretta turgida, Sars, Arch. Math. Naturv. Christiana, vol. 18, no. 3, p. 62, 1896.

Specific characters.—Female: from the side: Rather boldly arched, dorsal margin forming broadly rounded apex slightly behind middle, height equal to two-thirds of length, extremities broadly and equally rounded; ventral margin of left valve somewhat more sinuated than that of right; anterior margin of right valve with broad hyaline border, anterior margin of left valve with nar-

rower hyaline border; anterior margin of each valve with about fourteen long, slender radiating septa. From above: Moderately tumid, breadth greater than height, broadest behind middle; right valve projecting beyond left at each extremity; anterior extremity pointed, the posterior broadly rounded. Surface of valves sparingly hairy, very faintly pitted, the pits so indistinct that surface may appear smooth. Length 0.80, height 0.53, breadth 0.56 mm. Natatory setae of second antenna extend slightly beyond tips of terminal claws. Maxillary spines with slender, delicate teeth; terminal segment of maxillary palp two times longer than wide, slightly narrowed distally. Terminal claw of scratch-foot long, geniculate, delicately pectinate, one-half length of penultimate segment. Caudal ramus almost straight, twenty times longer than width at dorsal seta, dorsal margin smooth, dorsal seta delicate, one-fourth length of irregularly curved, seta-like subterminal claw, removed from claw by one and one-half times width of ramus; terminal claw curved, two-thirds length of ramus; terminal seta absent.

Male: unknown.

Occurrence.—Beaufort, North Carolina (Gallant's Pt. in reservoir of flowing fish-factory well, collected by L. F. Shackell, July, 1923).

Distribution.—Previously recorded from South Africa, Australia, New Zealand, China, Madagascar, Sumatra.

Genus *Candonocypris* Sars, 1895

A somewhat modified description of the genus is presented in the present account in order to include the four North American species *Cypriconcha barbata* (Forbes), *Cypriconcha macra* Blake, *Eucypris serrato-marginata* Furtos and an interesting new species from Florida, *Candonocypris pugionis*.

Elongated, exceeding 1.5 mm. in length, height *generally* less than one-half of length, moderately compressed, margin of valves smooth *or serrate*. Anterior and posterior extremity of each valve with distinct ridge between rather broad inner duplicature and submarginal line, the latter removed distinctly from margins. Natatory setae of second antenna ordinarily under developed, never extending beyond tips of terminal claws. Maxillary spines strong, two in number, *generally* smooth; terminal segment of maxillary palp in some cases broadened distally, *in others cylindrical, longer than broad*. Claw of scratch-foot very strong. Caudal ramus well devedoped, dorsal margin *ordinarily* denticulate, the teeth in some cases quite delicate, uniformly arranged, in other cases stronger, arranged in groups.

G. W. Müller (1912) lists the following four species: *C. bicornis* (Müller), *C. voeltzkowi* (Müller), *C. assimilis* Sars and *C. candonoides* (King). Subsequently Lindner (1920) added *C. ferdinandi* and Gauthier (1929) *C. bicornis laevis*... From the available descriptions and figures it is quite evident that *Cypris venusta* and *Cypris flabella* reported by Vavra (1898) should also be included in the genus. *Eucypris serrato-marginata* Furtos departs from the older generic analysis in the character of the valve

margin, which is serrate instead of smooth. The new *Candonocypris pugionis* has, in addition to serrate valve-margins, both maxillary spines toothed instead of smooth as described for all other species. A careful comparison of the two species of *Cypriconcha* (Sars, 1926 and Blake, 1931) with members of the genus *Candonocypris* reveals the fact that but a single minor difference exists, namely that while in *Candonocypris* the distal segment of maxillary palp is broadened distally, in *Cypriconcha* this is cylindrical. Further, the character of prehensile palps and penis in the two genera show a surprising

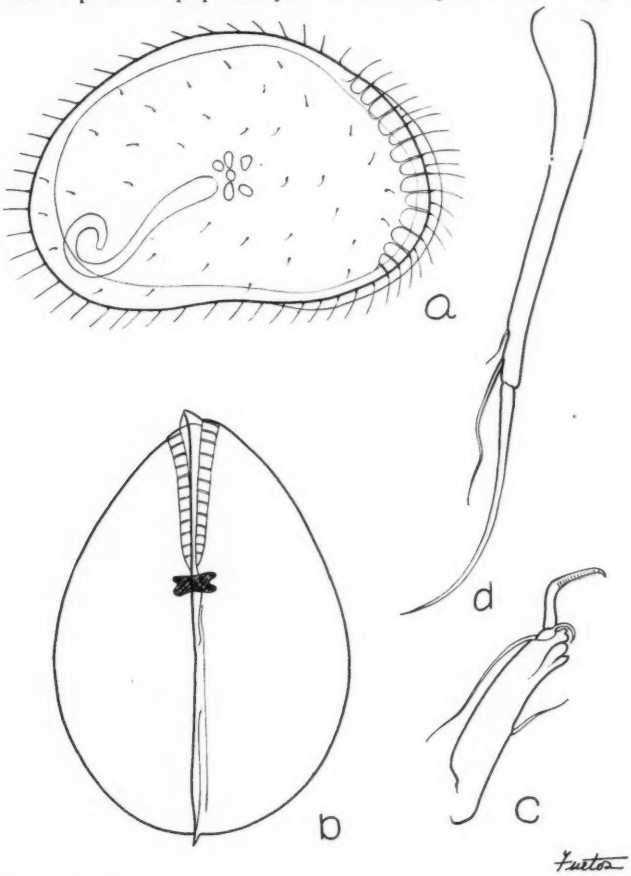


Fig. 6. *Cypretta turgida* (Sars): *a*, right valve, adult female; *b*, adult female, viewed from above; *c*, distal portion of scratch-foot; *d*, caudal ramus.

resemblance. It is therefore the opinion of the author that the genus *Cypriconcha* be discarded.

In view of the augmented list of species submitted above, a summary of the genus in the form of a key is inserted.

1. Anterior margin of valves serrate ---------- *serrato-marginata* (Furtos)
   Anterior margin of valves smooth ---------- 2
2. Posterior margin of each valve serrate ---------- *pugionis* n. sp. Furtos
   Posterior margin of valves not serrate ---------- 3
3. Each valve with one lateral spine ---------- *bicornis bicornis* (Müller)
   Lateral spines absent ---------- 4
4. Length of valves less than 2 mm. ---------- 5
   Length of valves at least 2 mm. ---------- 6
5. Valves highest in middle ---------- *assimilis* Sars
   Valves highest behind middle ---------- *candonoides* (King)
6. Infero-posteal angle of valves pointed ---------- 7
   Infero-posteal angle of valves not pointed ---------- 8
7. Sides slightly sinuate near extremities when viewed from above ---------- *bicornis laevis* Gauthier
   Sides gently convex near extremities ---------- *venusta* (Vavra)
8. Height of valves slightly exceeding one-half of length ---------- *flabella* (Vavra)
   Height of valves less than one-half of length ---------- 9
9. Posterior extremity narrowed ---------- 10
   Posterior extremity not narrowed ---------- 11
10. Length 6 to 7 mm. ---------- *voeltzkowi* (Müller)
    Length not more than 2.5 mm. ---------- *ferdinandi* Lindner
11. Terminal claw of caudal ramus gently curved ---------- *barbata* (Forbes)
    Terminal claw of caudal ramus slightly S-shaped ---------- *macra* (Blake)

Candonocypris serrato-marginata (Furtos, 1935)

Eucypris serrato-marginata, Furtos, Cenotes of Yucatan, Publication No. 457, Carnegie Inst. Washington, p. 107, figs. 106 to 111, 1935.

Specific characters.—Female: from the side: Elongated, height slightly less than one-half of length, highest in anterior third where dorsal margin forms rounded apex; ventral margin slightly sinuate; anterior extremity broadly rounded, posterior narrower; extremities of each valve with serrate margin, right valve with prominent spine at infero-posteal angle. From above: Spindle-shaped, breadth equal to two-fifths of length, broadest in middle; sides sinuate near equally pointed extremities. Surface of valves smooth, sparingly hairy, marginal hairs few in number along posterior extremity. Length 1.71 to 2.05 mm. Natatory setae of second antenna extend as far as distal third of terminal claws. Maxillary spines smooth; terminal segment of maxillary palp about as broad as long, slightly widened distally. Terminal claw of scratch-foot curved, smooth, one-third length of penultimate segment. Caudal ramus gently curved, eighteen and one-half times longer than narrowest width, distal half of dorsal margin faintly ciliated; dorsal seta somewhat less than one-half length of subterminal claw, removed from claw by one and one-third times width of ramus; claws delicately pectinate, the terminal approximating one-half length of ramus; terminal seta short, one-fifth length of terminal claw.

Male: unknown

Remarks.—The ridge between inner duplicature and submarginal line is well marked near the extremities of this species. This character, together with structure of the various appendages indicate that the form should not be referred to *Eucypris* and that it is a quite typical member of *Candonocypris*. The single specimen taken in Florida is but 1.71 mm. long, in contrast to that of Yucatan which measured 2.05 mm. Two immature males were also present in the sample from Florida. In these the testis had already formed in posterior valve-chamber, surface of valves longitudinally striate, and infero-posteal angle of each valve with a small spine. Marginal serrations not developed but were indicated inside the smooth border. Structure of scratch-foot and caudal ramus very closely approached the condition found in adult female of *C. serrato-marginata,* while differences in character of valves are probably of larval nature.

Occurrence.—Near Seminole City (Aug. 18).

Distribution.—Otherwise known only from the type locality, Valladolid, Yucatan (Xix Cenote).

Candonocypris pugionis sp. nov.

Fig. 7.

Specific characters.—Female: from the side: Elongated, height somewhat exceeding one-half of length, highest in front of middle; anterior extremity broadly rounded, the posterior narrowed, truncate; dorsal margin rather boldly arched to rounded apex, ventral margin straight; each extremity with broad flange similar in appearance to some species of *Chlamydotheca,* margin of anterior flange smoothly curved, that of the posterior distinctly serrate; submarginal line removed from anterior and posterior margins; pore-canals along anterior margin slender, closely approximated, each bearing a delicate hair; pore-canals along posterior margin widely separated, each with a long coarse hair; hyaline borders not evident. From above: Moderately compressed, breadth three-sevenths of length, broadest in front of middle, sides near pointed anterior extremity slightly sinuate, producing a beak-like appearance; posterior extremity narrowly rounded with flange of each valve approximated to form a sharp point; anterior flange of left valve projecting beyond that of the right. Surface of valves smooth, with numerous puncta bearing short, rather straight hairs. Color light with dark extremities and a dark patch on either side of ocular region. Length 3.90, height 1.90, breadth 1.70 mm. Natatory setae of second antenna extend to tips of terminal claws. Maxillary spines very coarsely toothed, apex of each spine rounded; terminal segment of maxillary palp slightly broadened distally, twice as long as broad at base. Basal segment of endopodite of second thoracic leg very hairy, armed with one pectinate seta extending almost to base of distal segment; distal margin of penultimate segment with a row of very slender cilia-like hairs and a long pectinate seta; terminal claw straight, dagger-like, distal half with short denticles. Penultimate segment of scratch-foot with a conspicuous fan-like struc-

ture with deeply serrate margin extending distally toward inner margin of claw; distal segment conical, one-fourth longer than width at base, terminating in a curious crown-like structure bearing a series of short pointed teeth; terminal claw pectinate, sharply geniculate, almost twice length of terminal segment. Caudal ramus straight, twenty-four times longer than narrowest width, dorsal margin finely denticulate; dorsal seta denticulate, slightly less than one-half length of subterminal claw, removed from claw by width of ramus; claws straight with bent tip, delicately denticulate, terminal claw somewhat exceeding one-half length of ramus; terminal seta also denticulate, one-third length of terminal claw.

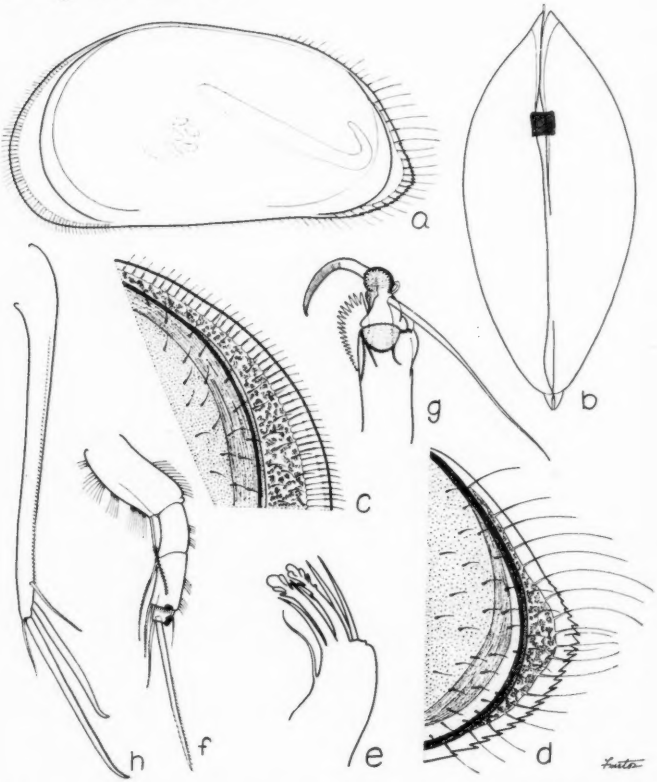


Fig. 7. *Candonocypris pugionis* new species: *a*, left valve, adult female; *b*, adult female, viewed from above; *c*, antero-dorsal margin, right valve; *d*, postero-ventral margin, left valve; *e*, third masticatory process of maxilla; *f*, second thoracic leg; *g*, distal portion of scratch-foot; *h*, caudal ramus.

Male: unknown.

Remarks.—Although this interesting form is placed in the genus *Candonocypris,* it differs from all previously described species in the character of maxillary spines and second thorcic leg, the terminal claw of the latter being quite distinctive.

Occurrence.—Type locality, four miles from Miakka on road toward Fruitville (highway pool, Aug. 17). Holotype, U. S. Nat. Mus. No. 71382.

Genus *Eucypris* Vavra, 1891

Elongate, moderately compressed to tumid forms, left valve enclosing the right, margin of valves smooth. Second antenna with natatory setae. Maxillary spines strong, two in number. Terminal claw of scratch-foot stout. Caudal ramus well developed, armed with two claws and two setae, dorsal margin smooth or denticulate; terminal claw generally exceeding one-half length of ramus, dorsal seta removed from subterminal claw by more than width of the claw. Parthenogenetic.

Eucypris arcadiae sp. nov.

Fig. 8.

Specific characters.—Female: from the side: Elongate, height slightly greater than one-half of length, highest in front of middle; ascending slope of dorsal margin boldly arched, descending slope straight, curving only to join posterior margin; anterior extremity broadly rounded, the posterior narrowed; ventral margin of right valve slightly sinuate, that of left convex; margins smooth with narrow hyaline border along anterior margin of left valve; submarginal line narrowly removed from margin, short pore-canals bearing slender marginal hairs. From above: Moderately compressed, breadth less than one-half of length, broadest in front of middle, left valve projecting beyond right at each extremity; sides sinuate near anterior end producing a somewhat pointed beak-shaped extremity; posterior extremity pointed, sides convex. Surface of valves smooth, hairless. Color light with a series of delicate longitudinal dark-blue stripes on lateral surface. Length 0.82, height 0.45, breadth 0.38 mm. Natatory setae of second antenna extend just beyond tips of terminal claws. Maxillary spines smooth; terminal segment of maxillary palp very slightly broadened distally, twice as long as width at base. Palp of first thoracic leg unsegmented, branchial plate with five rays. Terminal claw of scratch-foot gently curved, delicately pectinate, somewhat less than one-third length of penultimate segment. Caudal ramus straight, twenty-one times longer than narrowest width, dorsal margin moderately pectinate along entire length; dorsal seta slightly less than one-half length of subterminal claw, removed from claw by one-half width of ramus; claws straight, smooth, the subterminal weakly S-shaped, the terminal slightly less than one-half length of ramus; terminal seta well developed, equal to one-half length of terminal claw.

Male: unknown.

Occurrence.—Three miles west of Arcadia (Aug. 11). Several specimens, some immature, were taken. Holotype, U. S. Nat. Mus. No. 71383. Paratype, U. S. Nat. Mus. No. 71384.

Genus *Cypricercus* Sars, 1895

Elongated, moderately compressed to tumid forms, left valve enclosing the right, reproduction by sexual means with testis coiled in anterior valve-chamber. Maxillary spines strong, two in number. Caudal ramus somewhat better developed than in *Eucypris*, the terminal claw not exceeding one-half length of ramus.

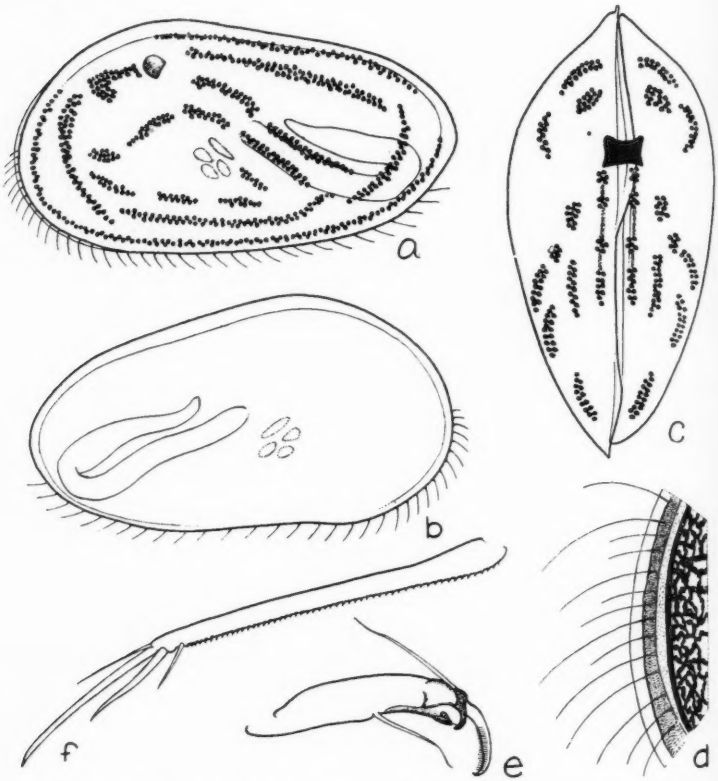


Fig. 8. *Eucypris arcadiae* new species: *a*, left valve, adult female; *b*, right valve; *c*, adult female, viewed from above; *d*, antero-ventral margin, left valve; *e*, distal portion of scratch-foot; *f*, caudal ramus.

Cypricercus mollis sp. nov.

Fig. 9.

Specific characters.—Male: from the side: Height five-ninths of length, highest in front of middle, ascending slope of dorsal margin boldly arched, apex rounded, descending slope somewhat sinuate behind apex, gently arched to posterior extremity; anterior extremity broadly rounded, posterior narrower, ventral margin straight; anterior margin of left valve with well defined hyaline border, margin bearing short hairs, submarginal line bearing longer hairs; an-

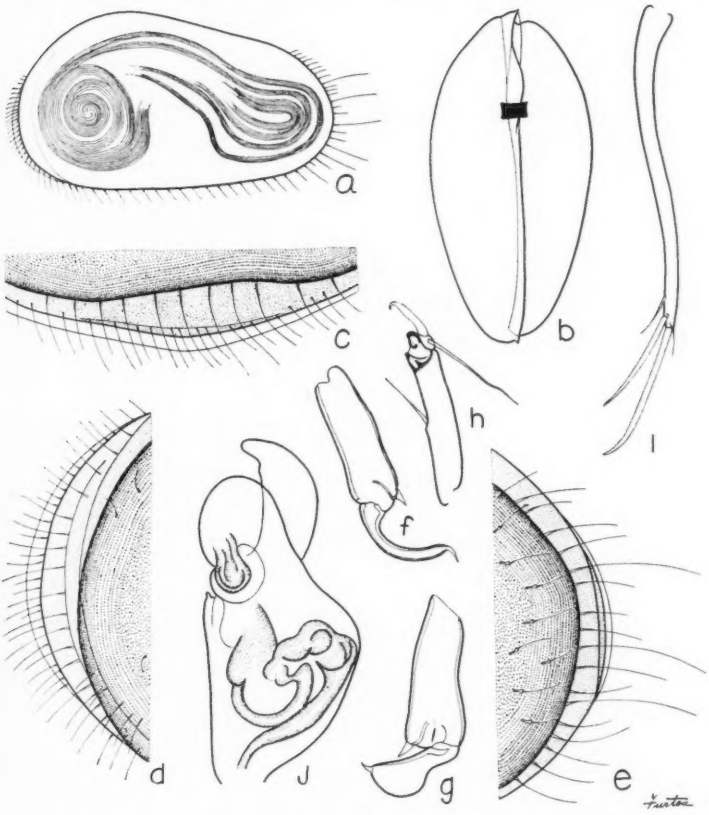


Fig. 9. *Cypricercus mollis* new species: *a*, left valve, adult male; *b*, adult male, viewed from above; *c*, antero-ventral margin, right valve; *d*, anterior margin, left valve; *e*, posterior margin, left valve; *f-g*, prehensible palps; *h*, distal portion of scratch-foot; *i*, caudal ramus; *j*, penis.

terior margin of right valve similar, but with hyaline border extending well along ventral margin; posterior margin of each valve with a very narrow hyaline border, marginal hairs lacking, long hairs arising from submarginal line. From above: Moderately compressed, breadth somewhat less than one-half of length, broadest in front of middle, left valve extending beyond right at each extremity; anterior extremity moderately rounded, posterior narrower. Surface of valves smooth, very sparingly hairy with slender hairs arising from short funnel-shaped processes. Testis with spiral coil in anterior valve-chamber connected to four U-shaped bands in posterior chamber. Length 0.80, height 0.44, breadth 0.40 mm. Natatory setae of second antenna extends to tips of terminal claws. Maxillary spines toothed, terminal segment of maxillary palp elongated, slightly narrowed distally, two and two-thirds times longer than width at base. Prehensile palps unequal, two-segmented, the stouter palp with propodus two and one-half times longer than width at distal end, dactylus short, proximal portion of outer margin sinuate, distal portion inflated, inner margin approximately straight; the narrower palp with propodus cylindrical, three times longer than wide, dactylus narrow, gently curved, longer than dactylus of larger palp. Terminal claw of scratch-foot strong, smooth, one-third length of penultimate segment. Caudal ramus slender, feebly S-shaped, twenty-three times longer than narrowest width, dorsal margin smooth; dorsal seta somewhat exceeding one-third length of subterminal claw, removed from claw by one and one-half times width of ramus; claws smooth, slender, very slightly curved, the terminal decidedly less than one-half length of ramus; terminal seta very short. Ejaculatory duct elongated, with thirteen regularly arranged crowns of short thick spines. Penis triangular, apex evenly rounded, subterminal lobe curved, attenuated.

Female: unknown.

Remarks.—The character of the penis closely resembles that of a male reported by Alm (1914) as *Eucypris affinis hirsuta*. The prehensile palps of the two forms are rather different, besides the valve-surface which in Alm's species is quite hairy.

Occurrence.—Type locality, forty miles west of Miami (wayside pool on Tamiami Highway, Aug. 18). One male was taken. Holotype, U. S. Nat. Mus. No. 71385.

Genus *Cypria* Zenker, 1854

Small, compressed forms, natatory setae of second antenna extend considerably beyond tips of terminal claws, distal segment of scratch-foot very little longer than broad, terminating in one long reflexed and two short setae. The genus is further divided into two subgenera, *Cypria* and *Physocypria*.

Subgenus *Cypria* Zenker, 1854

Margin of each valve smooth.

Cypria (Cypria) pseudocrenulata sp. nov.

Fig. 10.

Specific characters.—Female: from the side: Somewhat elongated, dorsal margin gently and evenly arched, extremities broadly rounded, the anterior narrower, height equal to seven-elevenths of length, highest behind middle, left valve somewhat longer and higher than right, ventral margin in each case straight. Margin of each valve similar, with marginal row of somewhat conical, short thick canals, each bearing a marginal hair at the broadened distal end; these canals more numerous along anterior margin, resembling tubercles so closely that at first glance the species appears to belong to *Physocypria,* are modified pore-canals and are present on *each* valve. Well developed hyaline border along anterior margin of both valves and along posterior margin of the

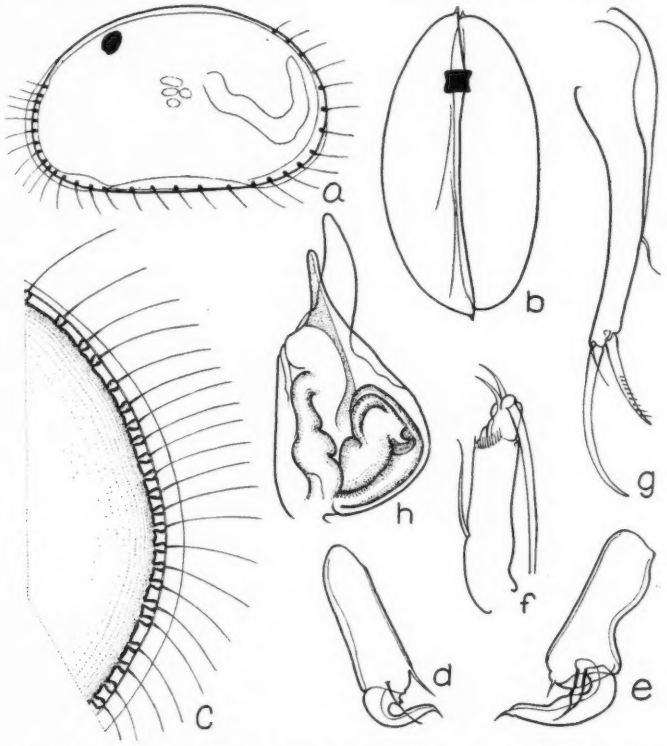


Fig. 10. *Cypria (Cypria)* pseudocrenulata new species: *a*, left valve, adult female; *b*, adult female, viewed from above; *c*, anterior margin, right valve; *d-e*, prehensible palps; *f*, distal portion of scratch-foot, female; *g*, caudal ramus, male; *h*, penis.

left. From above: Moderately compressed, breadth about one-half of length, broadest in middle; left valve projecting beyond the right at each extremity; extremities narrowly rounded, equal. Surface of valves smooth, with a few marginal hairs. Length 0.55, height 0.35, breadth 0.29 mm. Natatory setae of second antenna extend beyond tips of terminal claws by three times length of claws. The two short terminal setae of scratch-foot equal in length and as long as distal segment. Caudal ramus slightly curved, thirteen times longer than narrowest width, dorsal margin smooth; dorsal seta two-fifths length of subterminal claw, removed from claw by three times width of ramus; claws curved, the subterminal with a comb of denticles, the terminal smooth, less than one-half length of ramus; terminal seta delicate, one-fourth length of terminal claw.

Male: smaller than female, otherwise similar. Length 0.50, height 0.31 mm. Prehensile palps unequal, the larger with dorsal margin of propodus rather deeply sinuate, distal portion broadened with a narrow terminal lobe projecting beyond inner margin of moderately inflated curved dactylus; the smaller palp with propodus approximately cylindrical, dactylus shorter, narrower, hook-like. Caudal ramus similar to that of female. Ejaculatory duct with six crowns of spines. Penis triangular with two slender, subequal terminal lobes.

Remarks.—Cypria pellucida Sars of Brazil (1902) bears a rather close superficial resemblance to the above species but is somewhat larger (0.60 mm. in length), more boldly arched, posterior extremity when viewed from above more truncate and no mention of the curious pore-canals present in *C. pseudocrenulata*. Daday (1905) figured the male of *Cypria pellucida* and although this corresponds in shape and size to the species from Florida, the pore-canals are slender, situated between smaller hair-bearing tubercles, the prehensile palps of different shape and claws of caudal ramus more nearly equal in length, with subterminal claw smooth.

Occurrence.—Type locality, two miles from Dunedin on road to Tarpon (common in creek, Aug. 12). Holotype, U. S. Nat. Mus. No. 71386. Male paratype, U. S. Nat. Mus. No. 71387.

Subgenus *Physocypria* Vavra, 1897

Margin of either the right or left valve with small tubercles.

Cypria (Physocypria) gibbera sp. nov.

Fig. 11.

Specific characters.—Female: from the side: Rather stout, height about two-thirds of length, highest slightly behind middle; extremities broadly rounded, the anterior narrower; valves very unequal in height, dorsal margin of right valve broadly arched, that of the left more gently arched so that right valve forms distinct dorsal hump-like flange projecting conspicuously beyond the left along entire dorsal margin; free margin of right valve crenulate along all but midventral third, margin of left valve smooth; hyaline border along

anterior margin of right valve and along entire free margin of left. From above: Moderately compressed, breadth slightly less than one-half of length, broadest in middle; left valve projecting conspicuously beyond right at each extremity; anterior extremity narrowly rounded, the posterior broader; dorsal flange of right valve appears as broad band to right of hinge-line. Surface of

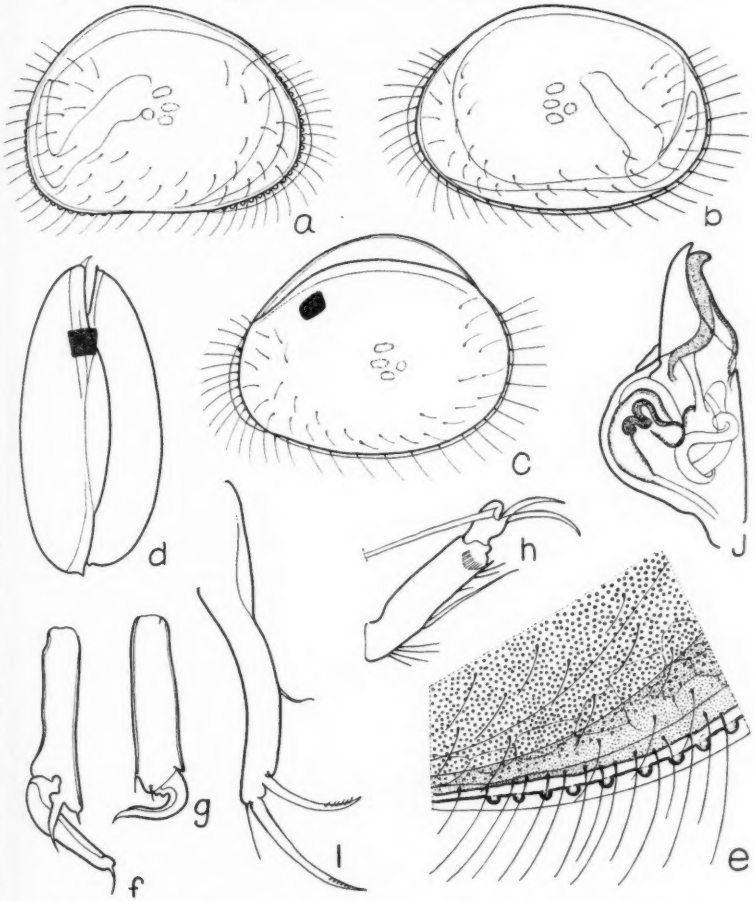


Fig. 11. *Cypria (Physocypria) gibbera* new species: *a*, right valve, adult female; *b*, left valve, adult female; *c*, adult male, viewed from left; *d*, adult female, viewed from above; *e*, antero-ventral margin, right valve; *f-g*, prehensile palps; *h*, distal portion of scratch-foot, female; *i*, caudal ramus, male; *j*, penis.

valves minutely punctate, covered with slender, rather long hairs. Length 0.60, height 0.40, breadth 0.37 mm. Natatory setae of second antenna extend beyond terminal claws by three times length of claws. The two short terminal setae of scratch-foot unequal in length, the longer twice length of distal segment, the shorter one and one-half times length of segment. Caudal ramus straight, ten times longer than narrowest width, dorsal margin smooth; dorsal seta one-third length of subterminal claw, removed from claw by two and one-half times width of ramus; claws gently curved, the subterminal with comb of slender denticles near tip, the terminal claw one-half length of ramus, very delicately denticulate near tip; terminal seta one-third length of terminal claw.

Male: shorter and higher than female. Length 0.54, height 0.42 mm. Prehensile palps unequal, propodus of the larger three times longer than width at distal end, produced distally as a blunt process projecting beyond outer margin of moderately inflated dactylus; propodus of smaller palp three and one-half times longer than wide, only very slightly broadened distally, dactylus short, slender, hook-like. Caudal ramus curved, otherwise similar to that of female. Ejaculatory duct with five crowns of slender spines. Penis triangular with two terminal lobes, one narrower than the other, both bent at tip in similar fashion.

Remarks.—Physocypria bullata Vavra (1898) has a similar dorsal flange on left valve and might readily be confused with the species from Florida. The two short terminal setae on scratch-foot of *P. bullata* are, however, much more unequal in length, and dorsal seta of caudal ramus much longer, being in fact longer than subterminal claw. *Physocypria pustulosa* Sharpe (1897), also characterized by a similar dorsal flange, may be distinguished from *P. gibbera* by the equal short terminal setae of scratch-foot, smooth terminal claw of caudal ramus and very distinct differences in prehensile palps and penis.

Occurrence.—Type locality, one-half mile east of Elfers (common in wayside pools, Aug. 24). Five miles west of Miakka City (wayside pool, Aug. 11); Lake Tsala Apopka at Hernando (Aug. 26). Holotype, U. S. Nat. Mus. No. 71391. Male paratype, U. S. Nat. Mus. No. 71392.

Cypria (Physocypria) fadeewi Dubowsky, 1927

Fig. 12.

Cypria (Physocypria) fadeewi, Dubowsky, Zool. Anz. Leipzig, Bd. 73, pp. 84-88, figs. 10 to 18, 1927.

Specific characters.—Female: from the side: Valves similar in shape, rather stout, left valve larger than the right, height about two-thirds of length, highest slightly behind middle; dorsal margin rather evenly and gently arched, ventral margin somewhat convex, extremities broadly rounded; right valve-margin weakly tuberculated along lower portion of anterior and posterior extremities and along all of ventral margin except middle, the tubercles project only slightly beyond margin; margin of left valve smooth; submarginal line widely removed from anterior and antero-ventral margins of left valve and narrowly removed from the posterior; pore-canals prominent; submarginal line not re-

moved from right valve margin; each valve with a very narrow hyaline border along antero-ventral and postero-ventral margins. From above: Moderately compressed, left valve projecting beyond right at each extremity; breadth equal to one-half of length, broadest slightly behind middle; extremities narrowly rounded, the anterior somewhat narrower. Surface of valves smooth, with scattered puncta bearing long curved hairs, margins moderately hairy. Length 0.65, height 0.45, breadth 0.32 mm. Natatory setae of second antenna extend beyond tips of terminal claws by four times length of claws. The two short terminal setae of scratch-foot unequal in length, the longer one and one-half times length of distal segment, the shorter only slightly longer than this segment. Caudal ramus gently curved, fourteen times longer than narrowest width, dorsal margin smooth; dorsal seta somewhat more than one-half length of the short subterminal claw, removed from claw by four times width of

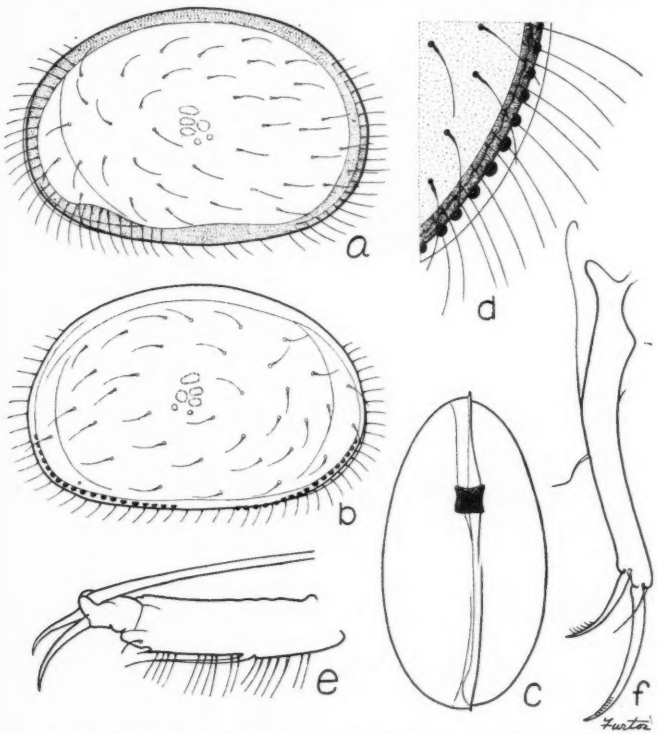


Fig. 12. *Cypria (Physocypria) fadeevi* Dubowsky: *a*, left valve, adult female; *b*, right valve; *c*, adult female, viewed from above; *d*, antero-ventral margin, right valve; *e*, distal portion of scratch-foot; *f*, caudal ramus.

ramus; claws curved, the subterminal with a comb of slender teeth near tip, terminal claw considerably less than one-half length of ramus, armed with a few weak denticles near tip; terminal seta one-half length of terminal claw.

Male: described by Dubowsky but not as yet taken in Florida. Presence of sperm-coils in female examined indicates that males were present.

Remarks.—The two females taken agree quite well with the description and figures of Dubowsky. The species may be quite readily mistaken for *P. denticulata* (Daday, 1905), *P. kraepelini* Müller (1905), *P. crenulata* (Sars, 1903), *P. armata* (Müller, 1898) and *P. xanabanica* Furtos (1935). Careful comparison of *P. fadeewi* with these species reveals the fact that while in *P. fadeewi* marginal tubercles are absent from midventral region of right valve, these are distinctly present in *P. denticulata* and *P. xanabanica;* further, tubercles are present only along anterior margin of *P. crenulata,* and along anterior and posterior margins of *P. kraepelini;* in addition to this *P. kraepelini* is distinctly broader when viewed from above; finally, *P. fadeewi* may be distinguished from *P. armata* by the character of dorsal seta of caudal ramus, which in the latter form is considerably longer than subterminal claw.

Occurrence.—North tributary of Caloosahatchee River at Labelle (Aug. 10).

Distribution.—Otherwise known only from the Sewerny-Donetz River in Russia.

Cypria (Physocypria) exquisita sp. nov.

Fig. 13

Specific characters.—Female: from the side: Rather stout, height about two-thirds of length, highest somewhat behind middle, extremities broadly rounded, the posterior slightly broader, left valve larger than right with dorsal margin somewhat less boldly arched, ventral margin of right valve straight, that of left convex; entire free margin of right valve tuberculated, the tubercles rather close together, almost spherical in appearance, not extending beyond margin except along mid-ventral region; margin of left valve smooth; submarginal line not removed from margin of either valve; anterior margin of each valve and postero-ventral margin of left with narrow hyaline border, the border on right valve exceptionally narrow. From above: Moderately compressed, left valve extending beyond right at each extremity. Surface of valves pitted, the pits ovoid in shape, between which appear a few small puncta bearing slender hairs; marginal hairs long. Length 0.63, height 0.42 mm. Natatory setae of second antenna extend beyond tips of terminal claws by almost four times length of claws. The two short terminal setae of scratch-foot unequal in length, the longer almost twice length of distal segment, the shorter only one-fourth longer than the segment. Exact proportions of caudal ramus not determined; subterminal claw with comb of very coarse, elongate denticles near tip; terminal claw one-half length of ramus, armed with a few weak denticles near tip; terminal seta one-third length of terminal claw.

Male: unknown but presence of sperm coils in female indicate existence.

Remarks.—The pitted valve-surface serves to distinguish this species from any previously described.

Occurrence.—Type locality, three miles east of Seminole City (Aug. 18). Two females were taken. Holotype, U. S. Nat. Mus. No. 71389. Paratype, U. S. Nat. Mus. No. 71390.

Cypria (Physocypria) globula Furtos, 1933

Physocypria globula, Furtos, Ohio Biol. Survey, Bull. 29 (Vol. V, No. 6), pp. 468-469, t. 16, figs. 1 to 9, 1933.

Boldly arched stout forms. Viewed from the right, left valve with conspicuous ventral flange enclosing right valve while the latter projects dorsally beyond the left. Anterior margin of right valve tuberculated, postero-ventral margin of same valve marked by three particularly large tubercles followed posteriorly by smaller ones. Hyaline border wide along anterior extremity of left valve, narrow along that of right. Surface smooth, sparingly hairy. Color varies from bluish-grey to yellowish-green with large reddish-brown spots. Length 0.60-0.65, height 0.40-0.43, breadth 0.42-0.45 mm. Natatory setae of second antenna extend beyond tips of terminal claws by three times length of claws. The two short distal setae of scratch-foot slightly unequal in length. Caudal ramus rather similar to that of *P. gibbera* but with terminal claw of caudal ramus smooth. Males common.

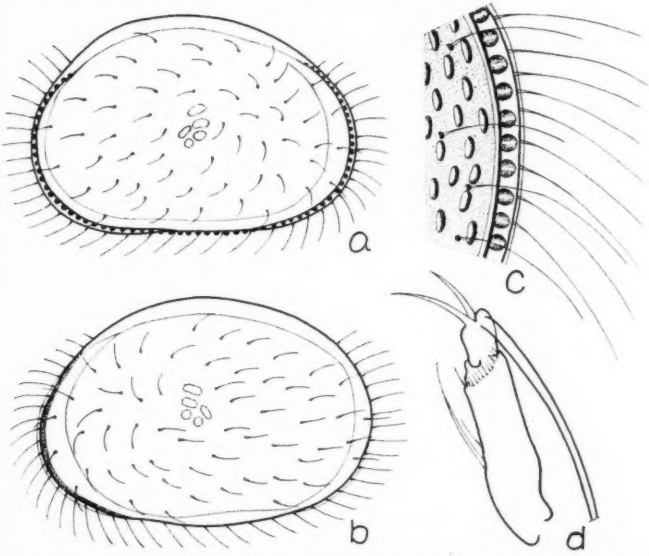


Fig. 13. *Cypria (Physocypria) exquisita* new species: *a*, right valve, adult female; *b*, left valve; *c*, anterior margin of right valve; *d*, distal portion of scratch-foot.

Occurrence.—Three miles from Naples (wayside pool on Tamiami Highway, Aug. 18; six miles south of Riverview (Little Bullfrog Creek, Aug. 16); Clewistown (drainage canal, Aug. 9); six miles from Labelle toward Clewiston (wayside ditch, Aug. 9).

Distribution.—Otherwise common in small lakes and ponds in Ohio and Massachusetts.

Genus *Cyclocypris* Brady & Norman, 1889

Small tumid forms, natatory setae of second antenna extend considerably beyond tips of terminal claws, distal segment of scratch-foot greatly elongated, terminating in one long reflexed and two shorter setae.

Cyclocypris sharpei Furtos, 1933

Cyclocypris laevis, Sharpe, Proc. U. S. Nat. Mus., vol. 35, p. 408, t. 50, fig. 5; t. 54, figs. 5 to 7, 1908.

Cyclocypris sharpei, Furtos, Ohio Biol. Survey. Bull. 29 (Vol. V, No. 6), pp. 460-461, t. 14, figs. 8 to 14, 1933.

Small, tumid, surface of valves smooth and with scattered hairs of moderate length. Length 0.47, height 0.33, breadth 0.33 mm. Color chestnut-brown which pigment upon closer examination resolves itself into three dorsolateral brown stripes on lighter background. Natatory setae of second antenna extend beyond tips of terminal claws by length of claws. Caudal ramus straight, ten times longer than narrowest width, dorsal margin smooth, dorsal seta absent, claws denticulated near tip, the terminal but one-third length of ramus, terminal seta elongated. Males common.

Occurrence.—One-half mile east of Elfers (wayside pool, Aug. 24).

Distribution.—Otherwise known from Ohio, Illinois, Indiana, New York.

Genus *Candona* Baird, 1842

Crawling forms devoid of natatory setae. Surface of valves smooth or pitted. Color white or light-yellow. Dactylus of prehensile palp fused to propodus producing an unsegmented appearance of palp. Penultimate segment of scratch-foot with one terminal seta, middle seta lacking; terminal segment short, ending in three setae of unequal length. Caudal ramus well developed, with two claws and two setae.

Candona balatonica Daday, 1894

Fig. 14

Candona balatonica, Daday, Math. Term. Ertes., vol. 12, p. 144, 1894.

Candona balatonica, Müller, Zool., vol. 30, p. 34, t. 7, figs. 18, 20, 21, 23, 24; t. 8, figs. 1 to 3, 1900.

Specific characters.—Female: from the side: Elongate, posterior end obliquely truncate, valves quite similar, height slightly less than one-half of length, highest behind middle; anterior margin broadly rounded, ascending slope of dorsal margin gently curved to rounded apex, descending slope steep.

posterior margin narrowly rounded, ventral margin sinuate; submarginal line not removed from margin. From above: Moderately compressed, left valve longer than right, projecting well beyond right at anterior end, slightly so at the posterior. Surface of valves smooth, hairless except for short delicate marginal hairs. Length 0.90, height 0.50 mm. Well developed black eye evident. Medial-distal seta of penultimate segment of mandibular palp smooth. Penultimate segment of scratch-foot divided, shortest distal seta three and one-half times longer than terminal segment. Caudal ramus curved, thirteen times longer than narrowest width, dorsal margin smooth; dorsal seta

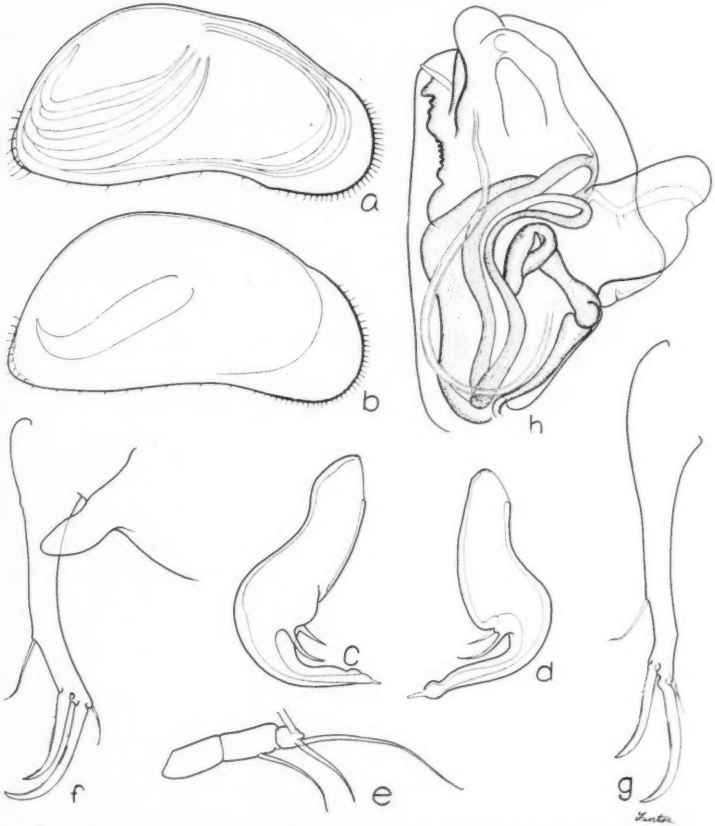


Fig. 14. *Candona balatonica* Daday: *a*, right valve, adult male; *b*, right valve, adult female; *c-d*, prehensile palps; *e*, distal portion of scratch-foot, male; *f*, caudal ramus and genital lobe, female; *g*, caudal ramus, male; *h*, penis.

two-thirds length of subterminal claw, removed from claw by two and one-half times width of ramus; claws curved, subequal, weakly pectinate, the terminal distinctly less than one-half length of ramus; terminal seta somewhat less than one-third length of terminal claw. Genital lobe well developed, finger-like.

Male: larger than female, posterior region of valves broader, less truncate, postero-ventral angle broader; ventral margin of right valve more sinuate than that of left, submarginal line narrowly removed from posterior margin of left valve. Length 1.05, height 0.51 mm. Prehensile palps quite similar, stout, falciform, each propodus with outer margin sinuate and broadened distally to curved attenuate dactylus. Caudal ramus straighter than that of female. Ejaculatory duct with five widely separated crowns of slender spines. Penis broadly triangular with short rounded terminal lobe, lateral lobe roughly mitten-shaped.

Occurrence.—Four miles from Dunedin toward Tarpon Springs (wayside pool, Aug. 24); one and one-half miles east of Elfers (wayside pool, Aug. 24); three miles south of Venice (Aug. 17).

Distribution.—The foregoing are the first records for Florida and the Americas. The species heretofore had been reported from Hungary, Germany, Sweden, and Turkestan.

Candona annae Mehes, 1913

Fig. 15.

Candona annae, Mehes, Bull. Soc. Neuchateloise Sciences Naturelles, vol. 5, pp. 639-663, 1913.

Specific characters.—Male: from the side: Elongate-reniform, height slightly less than one-half of length, highest in posterior third; anterior margin rather narrowly rounded, the posterior quite broad, ascending slope of dorsal margin slightly sinuate behind anterior third, rising thence to rounded apex in posterior third followed by steeper descending slope to posterior margin, ventral margin sinuate; submarginal line removed from entire free margin, pore-canals short, more numerous along anterior margin. From above: Compressed, breadth about one-third of length, broadest behind middle, sides sinuate near pointed anterior extremity, posterior extremity narrowly rounded; left valve extending clearly beyond right at each extremity. Surface of valves smooth and glistening, bluish-irridescent, puncta lacking, hairless except for delicate marginal hairs, the last quite elongated along the posterior margin. Length 0.90, height 0.46, breadth 0.31 mm. Medial-distal seta of penultimate mandibular palp segment smooth. Prehensile palps unequal, the larger with outer margin of dactylus greatly inflated, distal portion of inner margin moderately inflated; propodus of smaller palp longer, dactylus narrower, more falciform. Penultimate segment of scratch-foot undivided, distal segment short, very little longer than broad, the two shorter terminal setae very unequal, one very short, curved, only slightly longer than distal segment. Caudal ramus straight, fourteen times longer than narrowest width, dorsal margin smooth; dorsal seta three-sevenths length of subterminal claw, removed from claw by three times width of ramus; claws curved, weakly denticulate, about

equal in length, the terminal one-half length of ramus; terminal seta very short. Ejaculatory duct with five widely separated crowns of slender spines. Penis triangular with broad base, apex rounded, lateral lobe rectangular.

Female: described by Mehes but not taken in Florida. From the side less broad in posterior region, otherwise quite similar to male.

Remarks.—The single male taken in Florida agrees quite well with the figures and description of Mehes except for two minor details. The valve surface is given by Mehes as sparingly hairy and the terminal seta of caudal

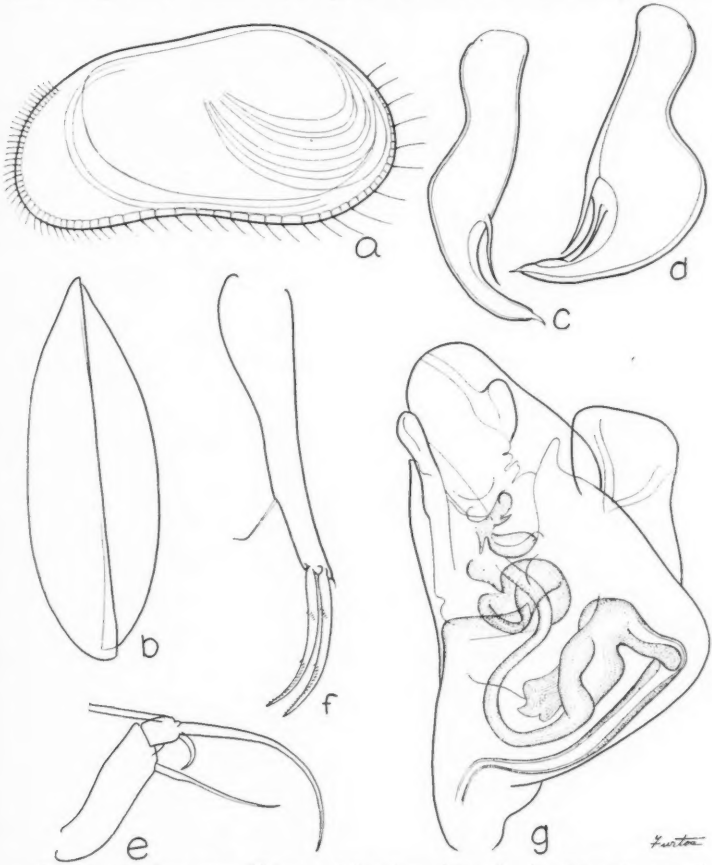


Fig. 15. *Candona annae* Mehes: *a*, left valve, adult male; *b*, adult male, viewed from above; *c-d*, prehensile palps; *e*, distal portion of scratch-foot; caudal ramus; *g*, penis.

ramus not shown in his figure. This seta is, however, so delicate, that it was almost overlooked in the Florida specimen, and it is quite possible that the same may be true in the case of those from Columbia.

Occurrence.—Three miles north of Fort Meyers (flowing wayside ditch, Aug. 17).

Distribution.—This species otherwise is known only from the United States of Columbia (South America).

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The Naiad Fauna of the St. Joseph River Drainage in Southwestern Michigan

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In view of the decided changes which have occurred in the Naiad fauna of the St. Joseph River drainage due to domestic sewage, industrial wastes, water-power development, and the depletion of the fauna as a result of excessive clamming operations, it seems advisable to summarize the data contributed by other workers, notably Call (1900), Wenninger (1921), and Dolley (1933), and to add data available from my own records. It is unfortunate that no careful survey was made of the fauna before the drainage was subjected to so many detrimental influences. However, though much valuable data will of necessity be lacking, we may still piece together the available information in an attempt to formulate a better knowledge of the fauna.

The first distributional list of the Naiades of the St. Joseph River was given by Call in 1900. The species reported by him are included in Table 1. Though this list includes the largest number of species in that table, it contains obvious inaccuracies. This may be due to several reasons of which perhaps the most probable are that Call may have received specimens erroneously labelled, or he may have listed species for this drainage which were really from the St. Joseph of the Maumee. I am inclined to think that the latter reason is the more logical since an examination of his list indicates that the six species at the bottom of that list, starting with *Obovaria subrotunda* and continuing through *Ligumia nasuta*, are all species common to the Maumee drainage, and drainages of Lake Erie in southeastern Michigan, but none of them are found in the St. Joseph River (Lake Michigan drainage). Wenninger (1921) published a preliminary report of the *Unionidae* based on collections probably made in the lower part of the St. Joseph drainage, because all the species represented are typical of large-river conditions, and the species missing from his list are mainly those common to creek and headwater conditions. Dolley (1933) added a few up-stream species to those reported by Wenninger. This is clear from the fact that *Elliptio dilatatus, Strophitus rugosus* and *Anodontoides ferussacianus* are common headwater forms. On the other hand, none of the lists, except Wenninger's, include *Proptera alata, Leptodea fragilis* and *Truncilla donaciformis*. These three species are known only from Lake Michigan or the mouth of the river itself where they occur as casual migrants from the lake.

TABLE 1

Comparative table to show species recorded from St. Joseph drainage.

	Wenninger, 1921	van der Schalie, 1930	Dolley, 1933	Call, 1900
Lampsilis ventricosa	x	x	x	x
Lampsilis siliquoidea	x	x		x
Actinonaias carinata	x	x		x
Ligumia recta latissima	x	x	x	x
Micromya iris	x	x		x
Proptera alata	x			
Leptodea fragilis	x			
Truncilla donaciformis	x			
Anodonta grandis	x	x	x	x
Lasmigona costata	x	x	x	x
Alasmidonta marginata	x	x	x	x
Amblema costata	x			
Fusconaia flava	x	x	x	x
Pleurobema cordatum coccineum	x	x		
Cyclonaias tuberculata	x	x		
Elliptio dilatatus		x	x	x
Lasmigona compressa		x		x
Strophitus rugosus		x	x	x
Actinonaias ellipsiformis		x		
Alasmidonta calceolus		x		x
Anodontoides ferussacianus		x	x	x
Truncilla truncata		x		
Dysnomia triquetra		x		
Obovaria subrotunda				x
Pleurobema clava				x
Obovaria olivaria				x
Micromya fabilis				x
Lampsilis fasciola				x
Ligumia nasuta				x

From the data at hand we may list the following twenty-three species as definitely established in the St. Joseph drainage:

Unioninae:

1. *Cyclonaias tuberculata* (Raf.)
2. *Amblema costata* (Raf.)*
3. *Fusconaia flava* (Raf.)
4. *Pleurobema cordatum coccineum* (Conrad)
5. *Elliptio dilatatus* (Raf.)

Anodontinae:

6. *Strophitus rugosus* (Swainson)
7. *Anodonta grandis* Say
8. *Anodontoides ferussacianus* (Lea)
9. *Lasmigona compressa* (Lea)
10. *Lasmigona costata* (Raf.)
11. *Alasmidonta calceolus* (Lea)
12. *Alasmidonta marginata* (Say)

Lampsilinae:

13. *Proptera alata* (Say)
14. *Leptodea fragilis* (Raf.)
15. *Actinonaias carinata* (Barnes)
16. *Actinonaias ellipsiformis* (Conrad)
17. *Micromya iris* (Lea)
18. *Ligumia recta latissima* (Raf.)
19. *Lampsilis siliquoidea* (Barnes)
20. *Lampsilis ventricosa* (Barnes)
21. *Truncilla donaciformis* (Lea)
22. *Truncilla truncata* Raf.
23. *Dysnomia triquetra* (Raf.)

To the above two doubtful ones may be added:

Lasmigona complanata (Barnes) and *Quadrula pustulosa* (Lea), for which there is inconclusive evidence since these were only seen in an accumulation of mussels at a commercial plant at Three Rivers, St. Joseph County. *Amblema costata* is reported in only one of the lists represented in Table 1, and there are no records in the Museum of Zoology at Ann Arbor to indicate that it occurs in the St. Joseph. Yet, it may occur there since there are records of its occurence in the Grand River in western Michigan. Additional information is desirable.

The species and localities visited in the St. Joseph River are charted in Table 2. Though not nearly sufficient data are available, we may provisionally group the species on a distributional basis, using information regarding the ecology and distribution of species from other drainages as a guide. The species in the St. Joseph drainage then roughly group themselves as follows:

I. Species limited to the mouth of the river:

Leptodea fragilis *Proptera alata*
Truncilla donaciformis

II. Species common to large-river conditions:

Cyclonaias tuberculata
Pleurobema cordatum coccineum
Amblema costata
Lampsilis ventricosa
Actinonaias carinata
Fusconaia flava
Truncilla truncata
Lasmigona costata
(Alasmidonta marginata)[1]
(Ligumia recta latissima)
(Anodonta grandis)
(Lampsilis siliquoidea)
(Micromya iris)

[1] Parentheses indicate the species may be present, but is not common.

TABLE 2

Survey of the Naiades of the St. Joseph River.

	St. Joseph R., 1 mi. s. of Litchfield, Hillsdale Co.	St. Joseph R., 6 mi ne. of Tekonsha, Calhoun Co.	St. Joseph R., at Tekonsha, Calhoun Co.	Hog Cr., 2 mi. se. of Union City, Branch Co.	St. Joseph R., 2 mi. s. of Leonidas, St. Joseph Co.	Nottawa Cr., 2 mi. w of Leonidas, St. Joseph Co.	St. Joseph, 3 mi. nw. of Three Rivers, St. Joseph Co.	Portage River, 4 mi. ne. of Three Rivers St. Jos. Co.	Prairie River, 2 m. se. of Three Rivers St. Jos. Co.	White Pigeon River, at White Pigeon, St. Jos. Co.	St. Joseph River, at Mottville, St. Joseph Co.	Spring Run, 3 mi. w. of Mottville, Cass Co.	Dowagiac Cr., at Niles, Berrien Co.	St. Joseph River, at St. Joseph, Berrien Co.
Cyclonaias tuberculata									2		1			
Fusconaia flava	2	1	4				1		1	2	14			
Pleurobema cordatum coccineum					1						4			
Elliptio dilatatus	1	8	20	2	8		2	1	5	2	8	2	4	
Strophitus rugosus	3	2	10		3	6	1		1		18			
Anodonta grandis	1						1							1
Anodontoides ferussacianus			1								1		1	
Lasmigona compressa	3											1	1	
Lasmigona costata	8	2	1								3			
Alasmidonta calceolus		4	3											
Alasmidonta marginata		1	1		3		1		2		2			
Actinonaias carinata		1	16	2	11	2			12	2	16			
Actinonaias ellipsiformis		7	9	1	15	1	23	6	3		7			
Micromya iris		10	2	2	13			14	3	3	1	5	2	
Lampsilis siliquoidea						2								
Lampsilis ventricosa		4	19		1	3		4		1	1			
Dysnomia triquetra					1									

III. Species common to medium-sized river conditions:

Anodonta grandis	*Dysnomia triquetra*
Lampsilis siliquoidea	*Actinonaias ellipsiformis*
Elliptio dilatatus	*(Micromya iris)*
Strophitus rugosus	*(Fusconaia flava)*
Alasmidonta marginata	*(Ligumia recta latissima)*
Lasmigona costata	*(Lampsilis ventricosa)*

IV. Species common to headwaters:

Strophitus rugosus	*Anodonta grandis*
Micromya iris	*Alasmidonta calceolus*
Actinonaias ellipsiformis	*(Anodontoides ferussacianus)*
Fusconaia flava	*(Lasmigona compressa)*
Alasmidonta marginata	

V. Species common to creeks:

Alasmidonta calceolus	*Anodontoides ferussacianus*
Lasmigona compressa	*Strophitus rugosus*

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Recent and Pleistocene Marine Shells of James Bay

Horace G. Richards

I.—Geographical Description

James Bay

James Bay is the portion of Hudson Bay that lies south of an imaginary line drawn from Cape Henrietta Maria on the west to Cape Jones on the east; the bay lies between 51° and 55° north latitude. From the most southern point in Hannah Bay to the entrance of Hudson Bay proper the distance is roughly 300 miles and the average width of the bay is 145 miles. On the east coast of the Bay from the mouth of the Moose River to Rupert Bay the coast line is exceedingly flat and the gradient seaward is slight. According to Melvill, who surveyed the Bay in the interest of its fisheries (1915):

> Hannah Bay is so shallow that with the exception of the channels of the Harricanaw and West Rivers, the whole bay is practically dry at low water. In fact, in many places it is difficult to say where the land begins and the sea ends, or vice versa.

Fig. 1. The extremely wide intertidal zone, Charlton Island, James Bay, Canada.

Further north on the east coast of the bay the character of the shore line changes and north of Sherrick Mountain the low marshy shores give place to a rocky, sandy coast fringed with many islands; when Cape Jones, at the north-eastern corner of the bay, is reached, the high land rises near the shore to about 1000 feet above the sea.

On the west coast of the bay the land has little relief as far as Cape Henrietta Maria and beyond. Northwest of the Albany River the coastal plain is more than 100 miles in width.

According to Kindle, who visited the region in 1923:

The seaward margin of the coastal plain is seldom well defined. Its location varies from day to day according to the height of the tide, which depends largely on the strength and direction of the wind. A strong wind from the sea may push the shoreline inland a half mile or more from the position it occupied during a period of calm weather; a breeze from the land may hold the flood tide far to seaward of its average position.

At low tide the sea retreats from two to six miles or more from the high tide shoreline. The broad intertidal zone which is thus laid bare at low tide appears to the eye quite flat. It is floored as a rule by rather well ripple-marked, sandy silt or clay which is plentifully sprinkled with glacial boulders.

To the landward of the true intertidal zone there is what Kindle calls "a neutral zone which belongs neither to the sea or the land for any extended period." Very shallow brackish water pools are characteristic of this zone. Freshwater mollusks were frequently found in such pools in the "neutral zone" on Charlton and Cary Islands. (See page 528). Still further landward there is a belt where the high tides reach only very rarely, and here the pools are dry and the bottoms are beautifully mud-cracked.

The salt pond zone with its very sparse salt-loving plant vegetation merges into a zone slightly higher where the ponds are scarce or absent and the surface is clothed with a dense growth of marsh grass making natural hay land. The marshy spots in this zone frequently support colonies of cattails and other freshwater plants. (Kindle).

Fig. 2. Beach, Charlton Island.

Even this zone is occasionally flooded by the bay. The forest or muskeg zone, in which the spruce *(Picea canadensis)* is dominant, is separated from the prairie-marsh zone by a belt of straggling willows.

It is very interesting to note the almost exact similarity of Kindle's zoning, which, he says, is characteristic of the greater part of the shoreline northwest of Moose River, with the zoning noted on the writer's visit to the salt marshes of Charlton and Cary Islands. There is, however, no muskeg on either of the islands. The forest floor is high and sandy and in most cases is covered with Reindeer Moss (*Cladonia* sp.).

Moose River

In its lower fifteen miles Moose River has a width of three to five miles, with a great many islands. The most important is Moose Factory Island, ten miles from the mouth of the river, upon which is located the trading post of the Hudson's Bay Company, the Anglican Mission School and Church, and the Indian Encampment. The island is high and wooded and there is not the muskeg characteristic of the mainland adjoining the Moose River and the west shore of James Bay.

On the mainland opposite Moose Factory, on the west side of Moose River, is the settlement of the Moosonee, the terminus of the recently completed Temiskaming and Northern Ontario Railway. Before the completion of this railway in 1931, to reach Moose Factory it was necessary to journey to some point on the transcontinental railroad (Canadian National) and then travel by canoe down one of the various tributaries of the Moose River, a distance of some 250 miles. The Hudson's Bay Company's supply boat makes an annual visit to James Bay, coming by way of Hudson Strait. Now, many supplies are shipped in by rail to Moosonee and transshipped to points in the Bay.

Islands

The largest island in James Bay is Agumiski and the second largest is Charlton. The latter was visited by the writer. It is about 15 miles long by 8 miles wide; much of it is wooded, and there is no underbrush, the forest floor being covered with Reindeer Moss. At the Hudson Bay Company's Warehouse the forest extends to the edge of a low bluff by a sandy beach. The north end of the island is flatter and marshy and there is the characteristic zoning as given above. North of Cape Hope Island the islands are generally devoid of trees, supporting a tundra association.

Tides

The following data are from the most recent (1935) surveys of the Canadian Hydrographic Service and from personal communications:

	Rise of tide in feet	
	Spring	Neap
Strutton Island	5¾	4
Stag Island	9	7¼
Moosonee	7¼	5¾
Shipsands	8¼	6¼
Moose Factory	7¼	5¾
Rupert House	6½	4½
Charlton Island	6	4¼

Certain phases of the tide are discussed by Melvill. The extreme flatness of the land and the consequent wide intertidal zone gives the impression of a much greater tidal interval.

II.—Geology

Pre-Pleistocene

Roughly speaking, the boundary between the James Bay Coastal Plain and the "Clay Belt" is the pre-Cambrian escarpment. The clay belt to the south

is the area underlain by the Pre-Cambrian rocks and covered by a clay of glacial origin. The clay belt, which is of great importance in the agricultural development of the land, extends south to the Height of Land (See Cole, 1932).

The James Bay Coastal Plain, north of the Pre-Cambrian escarpment, is underlain by Paleozoic and Mesozoic rocks. According to Kindle (p. 32)

> The gentle northerly inclination of this plain (Clay Belt), which is about five feet a mile, increases rather abruptly near the northern margin of the Pre-Cambrian rocks in the vicinity of the Abitibi and Missinaibi Rivers. The low escarpment which marks the northern border of the clay belt is distinctly the most pronounced topographic feature of the region. It crosses the Missinaibi River near Bulls Bay and the lower end of Coal Brook; the Abitibi at Abitibi Canyon; and is reported by aircraft observers to trend thence in a southeastern direction crossing the Ontario-Quebec boundary 40 miles north of the Canadian National Railroad.

The Paleozoic and Mesozoic rocks have been discussed by various writers including Kindle (1924), McLearn (1927) and most recently Dyer (1933) who is concerned particularly with the lignite deposits of Cretaceous age at Onakawana. These Paleozoic and Mesozoic rocks are overlain with till and marine clay of Pleistocene age, forming the uniformly sloping coastal plain which in the Moose River Basin has a width of from 75 to 100 miles.

Pleistocene-Postglacial

It has generally been thought that the marine clay mentioned above is of early post-glacial age, deposited as the Wisconsin ice retreated, causing Hudson and James Bays to rise because of the increased water released by the melting ice. The land was then lower than at present due to the weight of the ice. It is believed that there was a differential uplift of the land in post-Wisconsin time when the earth had recovered from the weight of the ice, greater to the north where the weight of the ice had been greater. This uplift would have caused the waters to retreat and Hudson and James Bays to become shallower. Abandoned shorelines up to 500 feet above the shore of Hudson Bay are evidence of this post-Wisconsin uplift.

These post-glacial marine deposits extend up the various tributaries of James Bay for a considerable distance, indicating that much or all of the coastal plain was submerged in post-glacial time. Years ago Bell (1898) and others recorded fossils from the Moose River and its tributaries. More recently McLearn (1927) traced these marine beds by means of the fossils south on the Missinaibi, Opazatika and Mattagami Rivers, all three being tributaries of the Moose, within 1¾ miles of the Pre-Cambrian escarpment. According to McLearn the fauna was abundant in individuals but sparse in species. *Macoma calcarea* and *Saxicava rugosa (S. arctica)* were the most common.

Kindle (p. 36) also traced the marine clay south along the tributaries of the Moose, the marine fauna being noted as far south as Coral Rapids on the Abitibi. Here the marine clays were 35 feet above the river at the foot of Coral Rapids and about 250 feet above tide. *S. rugosa* and *M.*

calcarea are reported on the east bank of the Missinaibi River about 14½ miles above the Opaztika River. On the lower part of the Moose a richer fauna was reported. He found eleven species along the west bank of the Moose River about three miles above Hay Creek. Similar localities on the lower Moose River were visited by the present writer in August, 1933, and will be discussed elsewhere in this paper. In addition, post-glacial marine fossils have been recorded from other tributaries on the west coast of James and Hudson Bays such as the Kapiskau (Wilson, 1903), the Ekwan (Dowling, 1902), the Winisk (McInnes) and others. I have recently received a few fossils from the Rupert River, 25 miles upstream from Rupert House, on the east side of James Bay collected by Mr. Frank Pentlarge and party who visited the region in the summer of 1934.

Stimpson (1861) reporting on some marine shells brought by Mr. Drexler from Cape Hope Island and Hannah Bay, believed that most of the shells found on the beaches and flats of lower James Bay were Pleistocene fossils, deposited at a time when the Bay was larger and deeper than at present. He records only three living species *(Mytilus edulis, Macoma fragilis (=balthica)* and *Littorina groenlandica (=rudis)* and since these together with a few specimens of *Acmaea testudinalis* were the only truly marine species collected alive by the writer, it seems very probable that Stimpson's interpretation is correct, although it is possible that other species may live in the deeper parts of James Bay; on account of the lack of dredging, our knowledge of the recent fauna of James Bay is far from complete. It is impossible to say from which stage of the Pleistocene these fossil shells date, but it seems probable that many of them date from the most recent marine invasion—in post-glacial time.

Pleistocene - Glacial Till and Gravel

Below the marine clay in most places is found unsorted drift or till, presumably of Wisconsin age. In a few places two drifts have been recognized (McLearn p. 29), but only where there is an interlying interglacial deposit is it possible to recognize the two tills. "Where known the later drift is from 20 to 40 feet thick, whereas the earlier drift is known to be at least 80 feet thick in places." (McLearn p. 30).

Dyer and Crozier (p. 53) who have obtained numerous drill-boring records in the region, say concerning the glacial series:

> Underlying the marine clays and forming an erosional contact with the underlying formation of Cretaceous age, is the glacial series. In its typical development the series consists of two till-sheets divided by an interglacial series of sands, gravels and stratified clays. . . On the Mattagami river west of the lignite fields the glacial deposits are very thick, in one drill hole reaching 280 feet. They consist of three till-sheets with two series of sands and clays (possibly interglacial) between them.

Pleistocene - Interglacial Deposits

McLearn reported interglacial deposits of peat along the various tributaries of the Moose River. In a few places it was possible to obtain plant fragments and fossil pollen and these were studied by Auer (1927), who reported

that the flora was that of a northern bog and that the conditions of interglacial time were probably much like those of the present; though its duration was probably not great.

McLearn found no marine shells in the interglacial deposits which he visited nor did Dyer and Crozier. Long before, Bell (1898) reported interglacial marine shells on the Opazatica River, and Parks (1889) found marine shells under the latest boulder clay on the Quattoboahegan River, while Tyrrell (1913) found that the latest boulder clay of the southwest side of Hudson Bay is charged with marine clay for 150 miles inland, reaching 500 feet above sea level. While many of these shells may be interpreted as of post-glacial age, covered by additional till due to a slight readvance of the ice, it seems possible that some of these shells may have been picked up from a late interglacial or early glacial James Bay, and redeposited by the Wisconsin ice.

More recently Coleman (1932) writes:

> Two years ago I found evidence near James Bay of two interglacial periods, an older one (Yarmouth) with peaty clay like that of Scarboro near Toronto, and a later one with marine fossils, probably of Sangamon age, corresponding to the shelly boulder clay of Tyrrell.

Later (1933—in a letter quoted by Dyer and Crozier), Coleman expands his evidence. Much of the evidence for the marine interglacial stage, he admits, is inconclusive, but

> On the shore of the river at Moose Factory conclusive proof was found. Lead-coloured, well stratified clay with marine shells rises about 4 feet above the river at low water stages of the tide. The top of this clay has been squeezed and crumpled, and angular pebbles have been pressed into it by the passage of an ice sheet over it, so that it must be interglacial.

Even this does not seem to the writer to be entirely conclusive. A slight readvance of the Wisconsin ice, or even in recent times the very thick masses of ice carried down the Moose River at the time of the spring "break-up" might have produced phenomena similar to those noted by Coleman. Therefore, while there is some evidence that there was an interglacial (pre-Wisconsin) marine deposit in the James Bay coastal plain, this evidence is not entirely conclusive. There is, however, evidence that the Wisconsin ice overrode an earlier marine deposit and redeposited shells; it does not necessarily follow that this earlier (interglacial) sea extended its limits beyond those of the present James Bay.

III.—Itinerary and Notes

In August, 1933, I visited several localities on the lower part of James Bay, travelling by automobile via Toronto and North Bay to the northern end of the Ferguson Highway at Cochrane, Ontario. I then took the recently completed line of the Temiskaming and Northern Ontario Railway to the "end of steel" at Moosonee, Ontario. Moosonee is a small town that has largely sprung up since the advent of the railroad; it is on the west bank of the Moose River about five miles from the island upon which is located Moose

Factory, the well known trading post of the Hudson's Bay Company and about ten miles from James Bay.

I arrived at Moosonee on the morning of August 17, 1933. Although it rained constantly, I was able to collect mollusks at several localities near Moosonee and Moose Factory. The water at both places was practically fresh, although after heavy winds from the north, salt water is said to be carried up the Moose River as far as Moosonee. The only living mollusks found were fresh-water species *(Lymnaea arctica* Lea, *Physa heterostropha* (Say), etc,) although fresh shells of *Macoma balthica* (Linné) and *Mytilus edulis* Linné suggested that these species were living not far away. In the sand flats on Butler Island (one mile from Moosonee) were noted many specimens of the freshwater mussel, *Lampsilis siliquoidea* Barnes. I was told that these were occasionally eaten by the Indians.

At low tide many marine shells were found on the beaches at both Moosonee and Moose Factory. Many of these shells appear to be very worn and they are probably Pleistocene fossils washed from the deposits along the Moose River mentioned above. A few days later I was able to collect some of these fossils in place along the banks of the Moose River below Moosonee.

Accommodations were provided at the Hudson's Bay Company Post at Moose Factory. On the following day at 9:30 a.m., I left Moose Factory accompanied by Mr. and Mrs. Frank R. Pentlarge, on the Hudson's Bay Company's boat "Fort Admadjuak," bound for Charlton Island. Charlton Island lies in James Bay about 85 miles from Moose Factory and 75 miles north of the mouth of the Moose River. Normally it is an eight hour trip, but owing to a stormy sea, it was necessary to anchor 15 hours near Shipsands, at the mouth of the Moose River, and proceed northward to Charlton Island the following morning.

For many years Charlton Island was the only port of call in James Bay for the supply steamer and all supplies had to be transhipped to the other points in the Bay. With the advent of the railroad many supplies are shipped from Moosonee, and consequently Charlton Island has lost some of its importance as a shipping port and the post has virtually been abandoned. Two important warehouses of the Hudson's Bay Company and the Post constitute the only buildings of the island. The wreck of a Dutch schooner adds to the loneliness of the scene.

Several days were spent on this island and specimens were obtained at a number of localities. Many of the shells found on the beach appear to be very worn and are probably Pleistocene fossils, deposited in Post-Glacial times when James Bay was larger and deeper than at present. The only living specimens found were *Littorina rudis* (Maton), *Macoma balthica* (Linné) *Mytilus edulis* Linné and *Acmaea testudinalis* (Müller).

Accompanied by an Indian boy, I visited "Saltwater Lake," near the northern end of the island. The lake is connected by an inlet with James Bay and the water probably fluctuates between fresh and salt according to the wind and tide. At the time of my visit the water was fresh and the fauna was made up of fresh-water species *(Gyraulus hornensis* Baker), *Physa gyrina* Say,

Lymnaea palustris ungava Baker, etc.) Fresh shells of *Macoma balthica* (Linné), *Littorina rudis* (Maton) and *Paludestrina minuta* (Totten) at the bottom of the lake suggested that at least part of the lake supported a marine or brackish fauna at one time.

At the invitation of Mr. James Watts, of the Hudson's Bay Company, I was able to spend a day on Cary Island, a small uninhabited island which lies about three miles northeast of Charlton Island. The shells collected on the beach here were similar to those found on Charlton Island. Fresh and brackish marshes on the east side of the island, directly connected with the Bay, supported an abundance of *Lymnaea palustris ungava* Baker.

The return on the "Fort Admadjuak" from Charlton Island to Moose Factory was made in a rough sea, but required only nine hours.

The remaining few days of the trip were divided between Moose Factory and Moosonee, and additional specimens were collected in this region. Finally, a canoe trip was made down the Moose River to Shipsands Island at the mouth of the river. On this trip a number of bluffs along the river were examined and some fossils obtained. The following section, on the left bank of the river below Butler Creek is typical (Fig. 3).

3 ft.—Gravel.
1 ft.—Silt with freshwater and land mollusks (sub-fossils).
3 ft.—Clay with marine fossils.

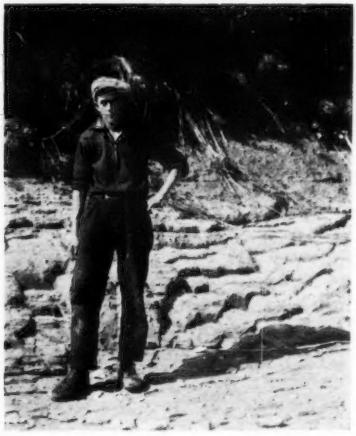

Fig. 3. Bluff along Moose River showing marine fossiliferous clay overlain by silt carrying land and freshwater "sub-fossils."

The beach drift at Shipsands was made up of a mixture of freshwater, land and marine species. At the time of my visit the water was fresh, although it undoubtedly becomes salty after continuous northern winds.

I left Moosonee on the morning of August 25th. The return trip was made entirely by rail, a forty-two hour trip from Moosonee to Philadelphia by way of Cochrane, North Bay, Montreal and New York.

IV.—Pleistocene and Recent Marine Mollusks From James Bay

No attempt has been made to give a complete synonomy; only synonyms that have appeared in the literature concerned with the James Bay region are recorded. Nor are the few notes on the distribution of the various species intended to be exhaustive. They are included merely to give a general idea of the distribution, Pleistocene and Recent, in James Bay and elsewhere.

Pelecypoda

Mytilus edulis Linné (Mussel)

Found alive at Charlton and Cary Islands; fresh shells found at Moosonee and Shipsands Islands and from Stag Island in Rupert River, about 25 miles northwest of its mouth.

Fossil at Charles Island, Moose River; Moose River 3 miles below Moosonee; Charlton Island.

Stimpson (1861) records the mussel alive at Cape Hope Island and fossil at Hannah Bay. Kindle has reported it as abundant (living) near Moose Factory and it has been reported from the Pleistocene from various tributaries of James Bay.

Saxicava arctica Linné
(*Saxicava rugosa* Linné)

Abundant on the beach at Moosonee and Moose Factory where it has probably been washed from the Pleistocene deposits along the river banks: also numerous on the beach of Charlton and Cary Islands where it is also probably of Pleistocene age.

S. arctica Linné and *S. rugosa* Linné appear to be synonymous. This is the most common species of the Pleistocene of the James Bay Coastal Plain and together with *Macoma balthica* (Linné) it is found as far inland as the southern limit of the coastal plain. It has been found fossil along the tributaries of the Moose (McLearn 1927, Kindle 1924, Baker 1911, Bell 1898, and others); it has been recorded from the Albany River; Wilson (1903) has recorded it on the Kapiskau River 125 miles from James Bay; it is also known from Ekwan River (Dowling 1902), the Winisk (McInness 1904) and elsewhere in the Hudson and James Bay region.

It has been reported living in Hudson Bay (Whiteaves 1901) and from Ungava (Dall 1886).

Serripes groenlandica (Beck)
(*Cardium groenlandicum* Gmelin)

One broken specimen found on the beach at Charlton Island; undoubtedly a fossil.

The only other records from the James Bay region appear to be from the

Pleistocene deposits on the Kapiskau River, 125 miles from the mouth (Wilson) and from similar deposits along the Winisk River (McInnes).

Whiteaves says "common at moderate depths in the Gulf of St. Lawrence and northward to Hudson Strait and Greenland and from Pleistocene deposits in Maine, New Brunswick, the Province of Quebec, Labrador and Greenland."

Cardium ciliatum Fabricius
(Cardium islandicum Chemnitz)

Found in Pleistocene deposits along the Moose River at Butler Island, Charles Island and 3 miles below Moosonee; abundant on the beaches of Charlton and Cary Islands (fossils).

Kindle reports this species (as *C. islandicum)* from the west bank of the Moose River 3 miles above Hay Creek; recorded from the Opazatika and Missinaibi (McLearn), from the Kapiskau (Wilson), the Winisk (McInnes) the Ekwan (Dowling) and elsewhere in the James Bay region.

According to Whiteaves this species lives in Hudson Bay.

Mya truncata Linné

Worn shells (fossils) found on the beach of Charlton Island.

Stimpson records this as a fossil at Cape Hope and Wilson lists it from the Kapiskau River; Baker found both this and *M. arenaria* Linné on the Mattagami; the latter species was not found by the writer. Reported from the Soweska, a branch of the Missinaibi (McLearn), the Ekwan (Dowling) and the Winisk (McInnes).

Bell dredged this species in Hudson Strait.

Astarte borealis Schumacker

Abundant on the beach of Charlton Island; a few specimens on Cary Island.

Stimpson recorded *A. arctica* as a fossil from Cape Hope. *A. arctica* Gray and *A. borealis* Schumacker have been confused and it is very possible that he had *borealis*. There appears to be no other record from the Bay.

Astarte striata Leach

Fossil on beaches of Charlton and Cary Islands; Stag Island, Rupert River (Pentlarge).

This species has been confused with *A. banksii* Leach and with *A. compressa* (Linné); the James Bay material appears to be typical *striata*. This species is apparently close to *A. laurentiana* Lyell.

Kennerlia glacialis (Leach)
(Pandora glacialis Leach)

One shell, slightly broken, was found in the bluffs on Charles Island, in the Moose River near Moosonee.

This species has been confused with *Pandora trilineata* Say and *P. gouldi-*

ana Dall. The latter two appears to be the same and distinct from *P. glacialis* Leach, which on the evidence of the hinge should be placed in a different genus, *Kennerlia*.

Kindle records *P. trilineata* Say from the Moose River 3 miles above Hay Creek. This locality is very close to the locality where the *glacialis* was found. According to Whiteaves "the specimens from the north shore of the Gulf of St. Lawrence . . . that have been identified by Packard with *P. trilineata* Say, are probably referable to this species [*K. glacialis* (Leach)]." In as much as *glacialis* is the species that would be expected in James Bay, it is conceivable that Kindle's specimen was *glacialis* also.

Pecten islandicus (Müller)

One shell and several fragments were found on the beach at Charlton Island and several fragments were obtained from Cary Island. These are undoubtedly Pleistocene fossils.

Stimson records this species as a fossil from Cape Hope and McInnes mentions it from the Winisk River. According to Whiteaves it has been found in the Pleistocene clays at Richmond Gulf on the east coast of Hudson Bay. Bell dredged it in Hudson Strait.

Macoma balthica (Linné)

(*Macoma fragilis* Fabricius)
(*Macoma fusca* Say)
(*Tellina groenlandica* Beck)
(*Macoma groenlandica* Beck)
(*Macoma tenera* Mörch)

Taken alive at Charlton and Cary Islands and fresh shells were found at various places on the Moose River between Moose Factory and Shipsands Island. Mr. Pentlarge sent me this species (living) from Stag Island in Rupert River about 25 miles northwest of the mouth.

As a Pleistocene fossil it was found in the bluffs along the Moose River at Butler Island and 3 miles below Moosonee.

Under the various names given in the synonomy this species has been reported from the Pleistocene at numerous localities in the James Bay region. Together with *Saxicava arctica* Linné it has been found as far inland as the southern limit of the coastal plain.

Macoma calcarea (Gmelin)

(*Macoma proxima* Sowerby)

Not found alive. Shells, probably Pleistocene, found on the beach at Moosonee, Shipsands and Charlton Islands and in the bluffs on the Moose River between Moosonee and Shipsands Island.

Recorded from the Pleistocene of various rivers in the James Bay region (Wilson, Baker, Kindle, etc.) and according to Whiteaves it has been found fossil (Pleistocene) "on the east coast of Hudson Bay, two or three miles up Little Whale River; at James Bay near Moose Factory; and at the Limestone Rapid of the Fawn Branch of the Severn River, Keewatin." It is part of the present fauna of Hudson Bay.

Leda pernula (Müller)

Next to *Saxicava arctica* Linné and *Macoma balthica* (Linné) this is probably the most abundant Pleistocene fossil in the region. Not seen alive, although rather fresh shells were found at Shipsands Island and Charlton Island.

Shells, probably Pleistocene, were found on the beach at Moosonee and Shipsands Island and in the river bluffs at Charles Island, Butler Island and 3 miles below Moosonee; common on the beach at Charlton and Cary Islands in James Bay; Stag Island, on Rupert River, 25 miles from mouth (Pentlarge).

Has been recorded from the Pleistocene of the Moose and tributaries (Kindle, McLearn, etc.); from the Kapiskau (as *L. buccata)* and from Hannah Bay (Stimpson). Bell dredged it, presumably alive, in Hudson Strait.

Fig. 4. *Yoldia abyssicola* (Torrell) x3. Moosonee, Ontario.

Yoldia abyssicola (Torrell)

Found at several places along the Moose River between Moose Factory and the mouth of the river.

This species is apparently very rare, having been reported only from the Pleistocene (Leda Clay) of Green Creek near Ottawa, Ont. and Saco, Maine (Dawson, 1872 p. 80). It is not known from the Recent. It has been referred to *Leda pygmaea* Munster, but a comparison of specimens shows it to be distinct. The James Bay specimens are identical with specimens labelled *Nucula abyssicola* from Saco, Maine in the collections of the Redpath Museum in Montreal.

GASTROPODA

Littorina rudis (Maton)
(Littorina groenlandica Möller)

Abundant, alive, in the intertidal zone of Charlton and Cary Islands in James Bay. A few of the shells found on the beach are worn and may be Pleistocene fossils.

Stimpson recorded this species (as *L. groenlandica)* alive at Cape Hope. It has also been taken alive in various parts of Hudson and Ungava Bays (Dall, Whiteaves.)

Acmaea testudinalis (Müller)

Shells, both living and fossil, were found on the beach at Charlton and Cary Islands.

It has been recorded from the Recent at Ungava Bay (Dall.)

Natica groenlandica Möller

One shell found on the beach at Moosonee where it had probably been washed from some Pleistocene deposit on the banks of the Moose River; frequent on the beach of Charlton Island (fossil).

Kindle found it on the Moose River 3 miles above Hay Creek (Pleistocene) and Bell obtained it in Hudson Strait (living.)

Buccinum tenue Gray

Very worn shells, undoubtedly fossils, found on the beach at Moosonee, Charlton and Cary Islands.

Reported as a fossil from Hudson Bay from the Winisk River (McInnes) and the Fawn River (Whiteaves). According to Dawson it is much more plentiful in the Pleistocene beds of eastern Canada than as a living shell and has been found as a fossil at St. John, etc., N. B., Rivière du Loup, Que., Labrador and Greenland.

Known from the Recent of the Gulf of St. Lawrence, Hudson Strait and Arctic seas generally.

Neptunea despecta Linné

One very young specimen was picked up on the beach at Charlton Island.

Cylichna alba (Brown)

One broken shell found in the Pleistocene deposit on Moose River 3 miles below Moosonee; found on the beach at Charlton and Cary Islands.

Kindle recorded this species from the Pleistocene on the Moose River 3 miles above Hay Creek.

It is known to be living off the Labrador and Greenland coasts.

Bela incisula Verrill

Found on the beach at Moosonee and Charlton Island. Both records are probably Pleistocene.

The synonymy of the species of *Bela* is somewhat confused and it is therefore difficult to state the records for the species. According to Whiteaves "It may be that the shells referred to *B. trevelyana* by Sir William Dawson are all *B. incisula*"; in this case it has been found (living) at Little Metis, Rivière du Loup and Murray Bay; and (fossil) in the Leda clay of Rivière du Loup and Labrador.

Bela americana Packard

One shell referred to this species was found on the beach at Moosonee.

Paludestrina minuta (Totten)

Characteristic of brackish water; very fresh shells were found on the beach at "Saltwater Lake" on Charlton Island and at the mouth of the Moose River at Shipsands Island. The water at both places was fresh, but at times becomes brackish.

BRACHIOPODA

Rhynchonella psittacea (Gmelin)

Found on the beach at Charlton and Cary Islands, probably fossil.

Abundant in the northern Pleistocene such as Rivière du Loup, Montreal, Labrador and Hudson Bay. In the James Bay region it has been recorded from Cape Hope (Stimpson) and from near Moose Factory (Bell).

In the Recent, it is abundant on stony or rocky ground throughout the northern seas, including Hudson Bay.

In addition to the species mentioned above the following have been recorded from the Pleistocene of the James Bay region, but were not seen by the writer:

Mya arenaria Linné—Mattagami River (Baker); Kapiskau River (Wilson); Winisk River (McInnes).

Nucula expansa Reeve—Hannah Bay (Stimpson).

Admete viridula (Stimpson)—Cape Hope (Stimpson).

Sipho ventricosus (Gray)—Mattagami River (Baker).

Yoldia glacialis Wood—Hannah Bay (Stimpson).

V.—Pleistocene (?) Land and Freshwater Fossils

Baker (1911) recorded nine species and land freshwater fossils from the Mattagami River and Kindle (1924) recorded *Sphaerium striatum* Lam. from the banks of the Missinaibi, but they were probably derived from the river silt above the marine clays and are consequently much later in age. Similar material has been reported elsewhere in the region; in August, 1933, some fossil land and freshwater shells were found in the river silt on top of the marine clays along the banks of the Moose River between Moosonee and Shipsands Island. All this material is younger than the marine postglacial deposits and much of it may be very recent. The following species were noted along the Moose River:

Discus cronkhitei anthonyi (Pilsbry)
Zonitoides arboreus (Say)
Zonitoides nitidus (Müller)
Retinella hammonis (Strom)
Cochliocopa lubrica (Müller)
Succinea ovalis Say
Succinea retusa Lea
Succinea avara Say
Lymnaea arctica Lea
Valvata tricarinata (Say)
Sphaerium solidulum distortum (Prime)
Musculium transversum (Say)

These same species live in the region today.

VI.—Salinity

RECENT

The following observations were taken by means of a hydrometer and were corrected to 4° C.

James Bay			
	August 17, 1933	¼ mile S. Shears Beacon	1.006
	August 19, 1933	Off East Point, Hannah Bay	1.016
		1 mile off Charlton Island	1.017
		H. B. Wharf, Charlton Island	1.019
	August 20, 1933	Off Cary Island	1.016

Moose River		
August 17, 1933	Moosonee	1.001
	Moose Factory	1.000
August 18, 1933	Inner Bar, Moose River	1.001
	Shipsands	1.001
August 23, 1933	Moosonee	1.000
	Butler Island	1.000
	Charles Island	1.000
	3 miles below Moosones	1.000
	Shipsands Island	1.000

This shows that James Bay does not have true ocean salinity, whereas Moose River is practically fresh. As stated above, a continued northern wind would cause the salinity on the Moose River to rise considerably. The marsh pools were nearly fresh and supported a freshwater fauna.

Of the five marine and brackish species found alive (*Macoma balthica* (Linné), *Littorina rudis* (Maton), *Mytilus edulis* Linné, *Acmaea testudinalis* (Müller) and *Paludestrina minuta* (Totten), the first three are more or less characteristic of brackish water.

Pleistocene

The Pleistocene fossils found at Charlton and Cary Islands are in most cases species that have been reported from Hudson Bay proper and suggest that James Bay in Post-Glacial time was deeper and more saline. The fossils found near the mouth of the Moose River also suggest more saline conditions than now exist in James Bay. In ascending the various rivers many of the species disappear and those that remain [*Saxicava arctica* Linné, *Macoma balthica* (Linné), etc.] are species characteristic of brackish water associations. It therefore seems probable that although the James Bay coastal plain was submerged in post-glacial time, the water was somewhat brackish, probably of a salinity similar to that of James Bay to-day.

VII.—Temperature

Recent

Air temperatures for Moose Factory and vicinity have been published by Kindle and others. The ten-year mean for Moose Factory, according to Kindle, is 31 ° F. The winters are very cold, and temperatures of -40 ° F. are not uncommon; nevertheless warm days are frequent in the summer months. In August, 1933, the month of my visit, the mean temperature at Moosonee was 60.1 ° F.; the highest recorded was 85 ° F. on the sixth of the month and the lowest 30 ° F. on the fifth.[1] Moose River is usually closed by ice from early November until early May and James Bay is frozen solid many miles out; in fact, the Indian caretaker on Charlton Island usually makes a trip to Moose Factory or Rupert House by dog sled over the Bay.

1 Data from the Meterological Service of Canada.

Melvill gives the following sea water temperature for James Bay:

July 27, 1914	Cape Jones	40
August 12, 1914	Twin Islands	45
August 24, 1914	Sabaskunika Bay	50
August 26, 1914	Factory Bay	50
August 27, 1914	Cape Hope	52
August 30, 1914	Boatswain Bay	54
September 16, 1914	Mouth Moose River	62

The following observations were made in August, 1933:

August 17, 1933	Moose River, Moosonee	66
	Moose Factory	67
August 18, 1933	Moose Factory	63
	Inner Bay, Moose River	62
	Shipsands, mouth of river	61
	¼ mile south Shears Beacon	57
August 19, 1933	Off East Point, Hannah Bay	55
	1 mile off Charlton Island	51
	Charlton Island (wharf)	51
August 20, 1933	Cary Island (James Bay)	51
	Marsh pool, Cary Island	68
August 21, 1933	Mud flats, Charlton Island	68
	"Saltwater Lake"	71
August 23, 1933	Moose River, Moosonee	71.5
	Moose River, Charles Island	73
	3 miles below Moosonee	70
	Shipsands Island (beach)	75
August 24, 1933	Moose River, Moose Factory	77

According to Melvill:

> The main body of water, undoubtedly, has a low temperature, possibly below 45° F. The comparatively higher temperatures found around the coast being on account of the numerous rivers and the general shallowness of the water.

The 1933 observations indicate clearly the low summer temperature of the open Bay. They also show rather clearly the variation of temperature in the Moose River. These are largely due to the direction of the wind and to the air temperature. The following data, while very meager, suggest a definite correlation between air and water temperatures at Moosonee:

date	max. air	river
August 17	73	66
August 18	59	63
August 23	83	71.5
August 24	83	77

The high temperature on the marshes and mud flats is what would be expected on a sunny day, even although the Bay itself was some 17 or 20 degrees lower.

Pleistocene

The chief difference between the Pleistocene and recent conditions are in depth and salinity. Temperature differences as indicated by the fauna are less marked, although the probabilities are that the water temperature was

slightly lower in post-glacial time on account of the closer proximity of the ice and the deeper water. As stated above, most of the Pleistocene fossils from James Bay are living to-day in Hudson Bay proper.

VIII.—Summary

Only five species were noted from the present marine molluscan fauna of James Bay. Of these, three are more or less characteristic of brackish water [*Paludestrina minuta* (Totten), *Littorina rudis* (Maton) and *Macoma balthica* (Linné)]. The other two [*Mytilus edulis* Linné and *Acmaea testudinalis* (Müller)] are more truly marine; however, further collecting, particularly in deeper water, will undoubtedly yield more species.

Pleistocene marine deposits have been noted along the Moose River and tributaries as well as along other rivers that flow into James Bay. These are thought to be of post-glacial age deposited as the Wisconsin glacier withdrew to the north and when the land was low because of the weight of the ice. The release of the load of the ice caused the land to rise and the sea to withdraw to the north. A layer of silt containing freshwater and land mollusks is evidence for this stage. Many shells found on the beaches of James Bay, particularly on Charlton and Cary Islands, are very worn, and have not been found living in the Bay. It is thought that these are Pleistocene fossils deposited when James Bay was deeper and more saline than at present; many of these species are at present living in Hudson Bay proper.

There is certainly evidence of a marine interglacial stage or at least that the Wisconsin ice rode over an earlier marine deposit and redeposited shells with the till; it does not necessarily follow that the interglacial sea extended beyond the present limits of James Bay. Other evidence of an interglacial sea may have been obliterated by the Wisconsin ice.

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NEW JERSEY STATE MUSEUM,
TRENTON, N. J.

New Mossmites, Chiefly Midwestern

Arthur Paul Jacot

Maxillaecoxae

The maxillaecoxae are a pair of quadrilateral plates situated distad of the labium in some Oribatidae. In my paper on Lichen-mining Mossmites (11, p. 466), these plates are called submaxillae, not having noticed the earlier term (8, p. 140). Grandjean advises me that two of the bristles of *Acaronychus trägårdhi* which I referred to (on the same page) as maxillaecoxal are labial, only the three in transverse row (left side of figure 10B) are maxillaecoxal.

Genus **Epilohmannoides** gen. nov.

Resembling Epilohmannia, but anal and genital apertures separated by a very narrow bar of the ventral plate which extends posteriad of anal aperture; coxae IV very broad, semicircular in ventral aspect, flanking anterior end of genital aperture; apodemata III and IV much narrower; lower edge of cephaloprothorax deeply lobed, so that median area of rostrum projects markedly [as in *Mucronothrus nasalis* (14, p. 374, fig. 1)].

Type: *Epilohmannoides terrae* sp. nov.

Epilohmannoides terrae sp. nov.

Size rather small, length of notogaster 0.33 mm., breadth 0.17 mm.; color pale; pseudostigmatic organ head fusiform, pointed, with a few weak burrs; interlamellar bristles long, stout; lamellar bristles about half as long; notogastral bristles shorter than lamellar; rostral bristles lacking or very short and closely appressed; exopseudostigmatic bristles short, stiff, inserted close to insertion on ridge close to insertion of legs I; palps with a long, curved spine springing from dorsal face of distal segment; tarsi I with a very stout depressed bristle the distal end of which is strongly hooked and reaches nearly to end of ungual hooks, nearly touching them; tarsi II with two similar bristles but less strongly curved; tarsi IV quite long with small hook.

Cotypes: Ten specimens from soil of pine-oak woodland, Bent Creek Experimental Forest, Buncombe County, N. Car.; slide 34F21r1.

Ceratoppia bipilis (Hermann)

This species is represented in America from Maine and New Hampshire to Florida by the following subspecies:

Ceratoppia bipilis spinipes (1, p. 496, pl. 17, fig. 22)

Banks described it under the name of Oppia. His *Oppia montana* is identical. The additional pair of posterior bristles are the somewhat longer

and more conspicuous mesal pair of postanal bristles. This is also evident from the figure (1, pl. 15, fig. 10). The length of the cusp relative to the lamella is a variable factor. Type specimens of *C. b. spinipes* have them equally long in large specimens, and with cusp shorter than lamella in small females. Length of bristles, relative or otherwise, is also a variable factor depending on size of animal or robustness. Thus I do not believe that even *Oppia canadensis* is distinct. The only question in my mind is relative to the "two bristles each side of anal aperture." In all specimens before me one pair is off the posterolateral corner of the anal aperture (as in the European species) and might thus be construed as lateral or posterior. I have not seen the types of *O. canadensis*. The rostrum is tricuspidate in all American material I have seen, as in Regensburg specimens. I described the east American form as *C. b. brevicuspis* (12) before discovering that Banks had nested his three eggs under Oppia.

Genus **Exoribatula** gen. nov.

As Oribatula (Type: *Oribatula tibialis* [Nicolet] see 9, p. 420) but the lamellae joined to distal end of the more or less developed tectopedia I so that the sides of the cephalon resemble those of Scheloribates.

Type: *Exoribatula biundatus* sp. nov.

Exoribatula biundatus sp. nov.

Size 0.18 mm. by 0.34 mm.; shoulder drawn out into a slight fold separated from edge of notogaster by a narrow groove, fold with two gentle undulations; pseudostigmatic organs clavate, directed anterolaterad, head barbulate, barbules arranged in longitudinal rows; notogaster with thirteen short, fine bristles; genital covers each with four bristles, bristle I peripheral; sternum well developed, bearing the six sternal bristles; ungues triheterohamate.

The most closely related American species known to me is *Oribatula florens* (3, p. 8; 3a, pl. 12, fig. 88) which is a typical Oribatula.

Cotypes: Nine specimens from closely browsed Andropogon pasture between wooded ridges two miles southwest of Bent Creek on Asheville-Brevard road, N. Car.; slide 34F11L.

Genus **Propeschelobates** gen. nov.

Resembling Scheloribates but no ridge between lamellae and insertion of rostral bristles, tectopedia I developed as a slender blade extending to insertion of rostral bristles and produced laterad of bristle insertion as a cusp; pteromorphae produced ventrad as a triangular tongue, as high as long, much as in Styloribates (10, pl. 10, figs. 95 and 97).

Type: *Oribatula albida* (4, p. 106).

I might supplement the original description by the following notes from one of the types loaned me by Dr. Ewing. The punctuation of surface is illusory; rostrum compressed; adalar porose areas (?) small, oval, with a channel nearly three times length of area extending anteriad and ending in a

bristle (?); posterior bristle of pteromorphae distant nearly twice length of adalar porose area from that area, inserted on transverse plane only slightly posteriad of that area; bristle mesad of adalar porose area quite distant from the area; sternum broad but anterior half very faint and indistinct; apodemata II-III with mesal end anterior to genital aperture; distal end of apodemata IV distant from that of II-III. Cotype not mounted for a good figure, the eggs obscuring some of the structural characters.

Peloribates vindobonensis (15, p. 339) described from Vienna, Austria, belongs in this genus. In Peloribates the pteromorphae are shorter (front to back) forming an angle where their posterior edge poins the notogaster; in Propeschelobates the posterior edge of pteromorphae flow gradually into outline of notogaster (compare figures on pages 338 and 339). Moreover Propeschelobates has minute bristles and porose areas of Scheloribates, while Peloribates always has very well developed, conspicuous bristles and quite differently arranged porose areas.

Scheloribates milleri sp. nov.

Figs. 1 to 4

Diagnostic characters: Size medium, females 0.39 to 0.4 mm. long, males considerably smaller and more slender than females; superficially resembling *Scheloribates lanceoliger* (3, p. 2) but with a raised ridge extending from area behind pseudostigmata posteriad around dorsal periphery of notogaster (Figure 1); adalar porose area much smaller, with a stout crossbar nearly filling it; adalar insertion about the length of its porose area posteromesad of it; pseudostigmatic organ head lanceolate, asymmetrical, with very short bristles along both edges and in two rows on face (often obscured by oil globules) (Figures 2 and 3).

Description: Rostrum slightly impressed at side, apex (in dorsal aspect) blunt; cephaloprothorax fairly long; its three pairs of major bristles slightly burred; rostral bristles well developed, extending their length distad of rostrum; lamellae bent, distal end slender, lamellar bristles extending mesad, well beyond rostrum; interlamellar bristles erect, inserted much closer to midthoracic suture than to lamellae; pseudostigmata with posterior edge projecting well beyond anterior edge of pteromorphae; organs sharply bent so that head is directed posterolaterad (as in *Scheloribates lanceoliger),* not surpassing sides of pteromorphae; exostigmatal bristles well developed, inserted near base of lamellae; acropleural porose areas fairly large, oval, well separated from lamellae.

Notogaster smooth, a cluster of "muscle scars" at posterior end anterior to raised ridge, others below the ridge, especially at sides; lateral pseudofissurae rather long, oblique; bristles a3, a4, and a5 at edge of raised ridge, as also their porose areas (Figure 1); anterior edge of pteromorphae directed obliquely backward, their sides appearing undulate in dorso/ventral aspects; ventral plate with anal aperture close to posterior edge; anal covers with well developed corners, anterior pair of bristles more remote than posterior pair; mesal postanal bristles more remote than anterior cover bristles; lateral post-

anals anteriad of angle of aperture; preanal bristles as approximate as mesal postanals; paramesal insertions small, less than length of a genital cover from same, more remote than preanal bristles; genital aperture surrounded by a broad frame, with anterior edge strongly angled, posterior edge strongly undulate; cover bristles 1 and 2 near anterior edge, not close together, bristles 3 and 4 nearer lateral than mesal edge, closer than bristles 1 and 2; apodemata well developed, apodemata I joined to sternum by a well-developed sternal arm; apodemata II-III attached to posterior end of sternum by a thickened bar; apodemata IV attached to genital frame by a short spur; anterior and middle sternal bristles inserted at edges of sternum which is quite broad posterior to apodemata I; mesal bristle of parasterna IV at edge of apodematal spur; bristles of labium and maxillaecoxae well developed.

Legs not unusual for the genus; tarsi I with ventral face bristles short-ciliate; dorsal quartette with the rudimentary bristle very faint, posterior bristle bent anteriad, anterior bristle stout, spinelike, bent back to cross the longest (Figure 4); tibiae I with dorsodistal knob acutely pointed, the minor bristle inserted on the point, ventroproximal edge strongly recurved to form a curved shelf on proximal end and a straight one distad; genuals I with the dorsodistal bristle long, fine, reaching nearly to insertion of major bristle of tibiae; femora I without flange. Femora II with well-developed flange which is incised at insertion of anterior bristle and produced into a sharp cusp at distal corner.

Cotypes: Forty-six specimens from prairie sod, Mount Logan, Chillicothe, Ohio; taken May 4th 1925 by August E. Miller, slide 32M21o7.

Ceratozetes subaquila (5, p. 412, pl. 15, fig. 19)

The following characters should be added to the specific description: Pseudostigmatic organs long, clavate in lateral aspect, but flat so as to appear bristlelike in edge view, distal end blunt, both edges ciliate far down the sides, head decurrent on the broad pedicel; edge of rostrum bilobed, with a median cusp (between the lobes) and a smaller cusp laterad of lobes; rostral bristles inserted into distal end of a short sclerotized ridge which widens ventrad (Figure 7r); anterior end of ventral plate wings produced as a slender horn which extends well beyond end of rostral bristle ridge (Figure 7vc); spine of tectopedia I long, extending over base of rostral bristle ridge, upper edge of tectopedium with a few weak serrations; anterior edge of notogaster overhanging base of prothorax as a slender eave; maxillaecoxae well developed; notogaster with the long lateral pseudofissurae somewhat transverse, followed by a well-developed but faint porose area; notogastral bristles present but short and fine, disposed very much as in Scheloribates; mesal end of apodemata I remote; mesal end of apodemata II-III joined to genital aperture by a short, faint, sclerotized band; mesal end of apodemata IV not connected with II-III.

It is evident from these characters that Ceratozetes is a primitive Anachipteria.

The species varies considerably in size locally, a length of 0.5 mm. being not uncommon.

Material examined: Three specimens from lower side of boards and/or logs lying on ground in more open part of Dodson's Woods, Urbana, Ill.; taken May 24, 1927 by A. E. Miller, slide 34M122o (length 0.47 to 0.51 mm.). Two specimens from under side of fallen, moist log, Dodson's Woods; taken August 18th, 1926 by Miller, slide 32M20.

This species closely approaches the European *C. gracilis* (13, p. 164, figs. 256 and 257) especially in the pseudostigmatic organs, but the development of the apodemata is quite different.

Ceratozetes subaquila subaquila curtispina form. nov.

Figs. 7 to 9

Differs from the species in that tectopedia I have the spur so short as to fall short of rostral bristle ridge (Figure 7); dimensions: females: 0.51 mm. long by 0.34 mm. broad; males: 0.467 mm. long by 0.3 mm. broad.

Cotypes: Fifteen specimens from prairie sod, Mount Logan, Chillicothe, Ohio; taken December 7th, 1925 by A. E. Miller, slide 32M58o4.

Ceratozetes subaquila longispina subsp. nov.

Fig. 10

Differs from the species in that rostrum has a deep, angular, median cleft, the corners sometimes appearing as closely opposed cusps (in dorso/ventral aspects) and giving the effect of lateral wings to edge of rostrum (Figure 10), in lateral aspect extending anteriad to a point; notogastral pseudofissurae parallel with median plane; mesal ends of apodemata I remote, joined by a slender bar curved posteriad at lateral ends; apodemata II-III joined to genital aperture frame by a short, broad, posteromesally directed bar; sternal bar extremely slender between genital aperture and apodemata II-III, indistinct and incomplete anteriad; dimensions of females: length 0.37 mm., breadth 0.217 mm.

Cotypes: Eighty-one specimens from leaf mould of isolated short-leaf pine stand in Andropogon pastures, two miles southwest of Bent Creek, Asheville-Brevard road, N. Car.; slide 34F10.2.

Also nine specimens from Great Falls, Va.; taken May 19th 1914 by Nathan Banks, slides 26B104c and -d.

Ceratozetes subaquila longispina minor form. nov.

Differs from the subspecies in that lamellar cusps are depressed; ventral plate spine barely developed beyond insertion of rostral bristles, not visible in dorsal aspect; spur of tectopedia I short; length of females 0.3 mm.

Cotypes: Ninety-nine specimens from soil of eighty year old pineoak woodland, north of laboratory buildings, Bent Creek Experimental Forest, Buncombe County, N. Car.; slide 34F21-15.

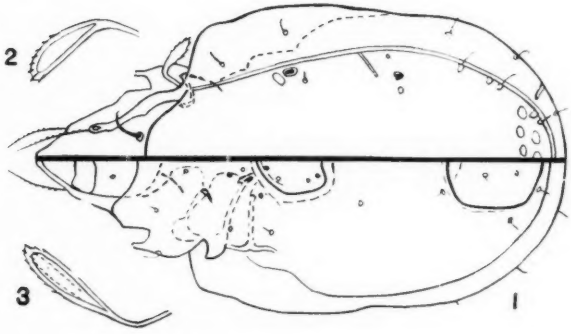
Anachipteria achipteroides milleri subsp. nov.

Figs. 5 and 6

Differs from the species (6, p. 119, pl. 8, fig. 16) in having no bristles on pseudostigmatic organ head, and in the smaller size: 0.42 to 0.47 mm. Differs from *A. a. australis* (7, p. 160, pl. 3, figs. 40 and 41) in the wider pseudostigmatic organ head, and in the well-developed lamellar cusp (Figure 5). The pseudostigmatic organs are often found with the head tucked under the lamellae, the distal end of the head is usually apiculate or variously broken in a ragged way.

Cotypes: Twenty-seven specimens from prairie sod, Mt. Logan, Chillicothe, Ohio; taken October 19th 1925 by A. E. Miller, slide 32M35o4.

Types with numbers including an F are to be deposited at the National Museum.

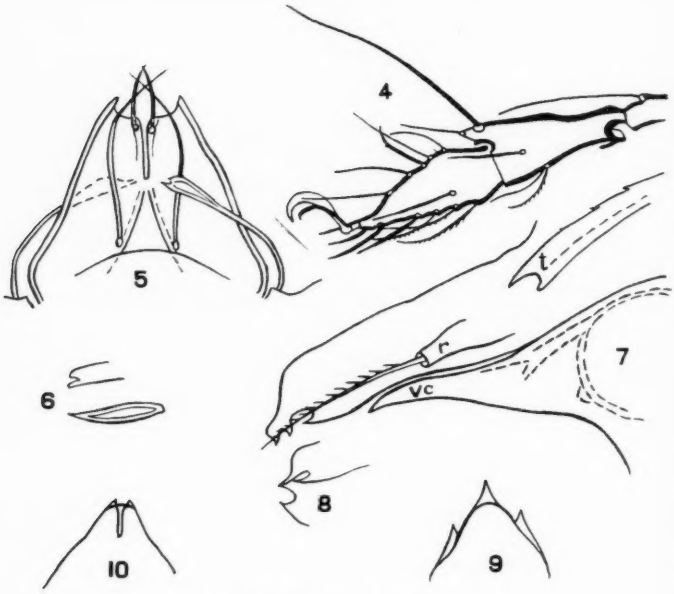


Scheloribates milleri sp. nov.

FIGURES

1. Dorso/ventral aspects, legs and mouth parts omitted; ratio x200.

2, 3. Pseudostigmatic organs; ratio x440.



Scheloribates milleri sp. nov.

FIGURES

4. Legs I; ratio x440.

Anachipteria achipteroides milleri subsp. nov.

5. Lamellae and pseudostigmatic organs; ratio x200.

6. Pseudostigmatic organ heads; free hand.

Ceratozetes subaquila subaquila curtispina form. nov.

7. Rostrum, rostral bristle base (r), anterior end of ventral plate (vc), and tectopedia I (t); ratio x440.

8. Rostrum ventrolateral aspect; ratio x440.

9. Rostrum, dorsal aspect; ratio x440.

Ceratozetes subaquila longispina subsp. nov.

10. Rostrum, dorsal aspect; ratio x440.

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The Winter of 1934-35 and Iowa Bob-Whites*

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The winter of 1934-35 was the sixth of a series of seasons during which field studies have been made on the wintering of the bob-white quail [*Colinus virginianus virginianus* (Linn.)] under Wisconsin and Iowa conditions. The data from this past season should not be looked upon, however, as representing merely one season's work among six, contributing in like proportion to the data already published.

Previous publications dealing with field data show winter mortality from various causes and of varying degrees of severity (Errington 1933a; 1933b; 1933c; Errington and Hamerstrom 1935). For 1934-35, the factors which brought about mortality may not differ in the main from the factors which have been observed to be chiefly operative before—starvation and predation upon over-populations. To this extent, the 1934-35 mortality suffered by wintering quail populations may be reminiscent of mortality already recorded.

But, for the 1934-35 season, the emergencies have been more drastic on a large scale than those which we have observed before. In 1934-35, there was a greater apparent interplay of ecological complexities. The field studies, even those of the most intensive sort, were beset by many more than the usual questions for which no recognizable answers appeared to be at hand.

A pronounced summer decline of bob-whites in southern Iowa may perhaps be attributed to the drought as much as to anything (Errington 1935b), though we cannot be too sure that the drought alone was responsible. Indeed, it may be strongly suspected that a great deal more happened than was evident on the surface.

Chinch bugs and drought combined damaged small grains and corn so severely that the bob-white population in some southern Iowa counties faced a food shortage before the winter began. Soybeans and a late growth of lesser ragweed *(Ambrosia artemisiifolia)* mitigated the crisis locally, but the food situation was on the whole very unsatisfactory for bob-white.

In the north-central and northern parts of the state, the chinch bug infestation was negligible, and the drought was broken sufficiently early to permit a fair corn crop. Pastures and hay crops were short, nevertheless, which resulted in unusually heavy pasturing of corn and stubble fields by livestock during the winter.

To sum up the pre-winter food picture for bob-white, we may say that in roughly the southern third of the state there was very little for the birds to eat except for what was locally adequate or was artificially supplied. The eastern portion of this strip represents what is normally Iowa's best quail range. An emergency feeding program was carried on by the Iowa Fish and

* Journal Paper No. J-280 of the Iowa Agricultural Experiment Station, Ames, Ia., Project 329.

Game Commission and the State Planning Board, and private individuals here and there did some feeding. To the north the food situation was much better, but northward the country becomes of the type favorable to ring-necked pheasants *(Phasianus colchicus torquatus* Gmelin) rather than to bob-whites.

December proved to be the month of greatest crisis, because of a combination of cold weather and snow which precipitated most of the wintering losses suffered by Iowa quail. The weather moderated in January, and subsequent snows and cold snaps were not attended by conspicuous mortality. An ice storm had covered all but the southern part of the state by January 19, and effectually sealed for many days much of the food on the ground, but surprisingly little mortality seemed to follow, despite observed temperatures down to 30 degrees (F) below zero.

The winter research program was planned by the author and Mr. F. N. Hamerstrom, Jr., with the purpose in mind of keeping in touch with the fortunes of the quail in the south and central portions of the state generally, as well as continuing intensive observations on a few specific areas. Unfavorable working conditions and the pressure of other duties soon forced us to modify our plans as concerned the scope of the investigations. Snow-blocked or ice-covered roads made some areas virtually inaccessible in the limited time available, and we were compelled further to limit our principal activities to a comparativly few areas.

Mr. and Mrs. Hamerstrom made observations in the southeast counties, while I confined my field activities to detailed studies on areas in the vicinity of Ames and Des Moines.

The census technique used was largely that of direct enumeration (Errington 1933a, pp. 1-11).

We may now turn to a brief presentation and discussion of the data obtained.

South-eastern and South-central Iowa

Area "A"—Area of 800 acres about 10 miles south of Ottumwa. Third season under observation.

There was a surviving population in the vicinity of 148 on this area last spring, or one bird per 5.4 acres. Mr. and Mrs. Hamerstrom obtained on November 17, 1934, a population check of about 116 birds in 9 coveys or one per 6.9 acres, a population considerably below the normal carrying capacity of the land as indicated by the spring population.

On December 11, the count was 54 in 6 coveys (9+12+9+8+6+10). Five quail had evidently been killed by foxes *(Vulpes fulva),* and an entire covey had disappeared under circumstances that pointed to imprisonment under the heavy ice-crusted snow. The birds surviving at this time were feeding on shocked corn, soybean stacks, cane tops, and to some extent upon squirrel-opened acorns in the woods. The crop of weed seeds was very poor.

By January 27, Mr. and Mrs. Hamerstrom and Deputy Wardens Updegraff and Benson found 51 quail (10+10+4+17+10). A final

count of 32 (11+12+6+3) was made March 3 by Mr. and Mrs. Hamerstrom and Deputy Warden Benson, with the aid of Benson's dog.

It was apparent that the birds which formerly had been dependent upon weed seeds had shifted their ranges to utilize feed planted by man. A great part of the area was totally vacated by wintering quail by spring, and the 32 birds representing the last count were only a fraction of the population that could be accommodated under non-emergency conditions.

Area "B"—Area of about 1500 acres east of Bloomfield. Second season under observation.

Mr. and Mrs. Hamerstrom located 78 birds (11+7+10+14+16+8+12) or one per 19 acres on the area, on November 23, 1934, compared with the former population of 173 censused on March 3 and 4, 1934.

The next census was made on December 10, at which time but 37 quail (8+4+8+9+8) were found. Weedy growths were completely covered by snow. All coveys, with the possible exception of one of 8, were depending upon soybeans and grains in farmyards. The final census, on February 23, 1935, showed 32 birds, a bare remnant of the previous population.

Area "C"—Area of 740 acres near Lineville. Second season under observation.

Only one check was made this season, and that on January 5 and 6, 1935, by Mr. and Mrs. Hamerstrom. Farmers' reports indicated a population of 32 to 34; and these probable figures were substantiated by the field evidence. The food situation generally was very bad, but, even so, the area did not seem as well occupied as it should have been. In fact, one territory with good cover and an abundance of food—husked corn in piles—had no quail. Last season this area wintered 116 birds up to February 4.

Area "D"—Sample area of 700 acres, west of Albia. Second season under observation.

One visit by Mr. and Mrs. Hamerstrom, January 12, 1935, gave a count of 28 birds (12+16) or one per 25 acres, compared with a bird per 166 acres survival for the area by February 21, 1934.

Area "E"—Area of 1200 acres near Indianola. First season visited.

One check was made by Mr. and Mrs. Hamerstrom, on February 8 and 9, 1935. They found 49 birds (7+12+12+13+5), of which 42 had concentrated in the vicinity of one cornfield. The food supply here was good, but the rest of the area, from this standpoint, furnished quite uncongenial habitat.

Area "F"—Area of 800 acres near Valley Junction. First season visited.

Mr. and Mrs. Hamestrom by thorough search and aided by a good tracking snow were able to find only a total of 26 quail (5+7+6+7+1) on March 9 and 10, 1935. According to farmers and men who had been feeding the birds through the winter, a much heavier population, estimated at between

146 and 152 by March 1, had been present. It is very probable that a natural dispersal of the coveys took place in early March, as this has been recorded on other areas, for example, Areas "I" and "J." Critical scrutiny of the wintering information contributed by the farmers brings out the likelihood of some duplication of covey counts also, so the March 1 population may have been somewhat over-estimated. Further evidence that the estimates of the population wintering on the area were considerably too high is offered by the fact that most of the feeding stations, at which covey counts and estimates had been made, were situated on the edges of the sample area, with the most attractive habitats on the adjoining lands rather than on the sample itself.

Area "G"—Area of 1931 acres north-east of Ottumwa. Second season under observation.

A check made by Deputy Warden C. H. Updegraff on December 4 and 5, 1934, gave 87 birds (10+9+9+15+7+5+8+5+11+8) on an area having a population of about 239 on March 10 and 11, 1934. He noted one kill by a fox and another apparently by a Cooper's hawk *(Accipiter cooperi)*.

Area "H"—Sample area of about 1000 acres south of Fairfield. Second season under observation.

The observations on this area were carried on by Mr. Malcolm McDonald of Fairfield, and were continued throughout the winter. The coveys shifted a great deal, and their alternate absences and concentrations in specific territories made accurate censuses almost impossible.

As nearly as we can patch together the story from the notes available, the initial population for early December, 1934, amounted to about 60 birds or about 60% of the population present on March 22, 1934.

The wintering data may perhaps be handled best in groups:

Group I—Dec. 3, 5 birds in one covey and 10 in another; Jan. 15, 5; all gone by March 8. The smaller covey fed mainly on the beans of black locust *(Robinia Pseudo-Acacia)* and about a farmyard; the other covey also visited the farmyard until late December and then apparently stayed more with Group II.

Group II—Dec. 3, 12+8+possibly the covey of 10 from Group I part of the time; Dec. 20, 10+12; Dec. 22, 10+7; Dec. 29, 10; Jan. 15, 7+5; Feb. 23, 1; March 8, 1. The birds fed on soybeans, corn, and smartweed *(Polygonum)* for the first part of the winter; later they apparently moved elsewhere. Remains of one dead bird found—cause of death unknown.

Group III—The presence of a substantial population was noted Dec. 3 and 20, but no counts could be made. The principal attraction was a great abundance of black locust beans. The first approximate census was obtained on Dec. 22: 12+12+6 (some of these probably represented birds from Group II). Eleven were counted on Dec. 29; Jan. 15, 9+7; Mar. 8, 14. Remains of one bird were found in an old owl pellet, probably from fall.

CENTRAL AND SOUTH-CENTRAL IOWA

Area I—Area of about 1000 acres south-east of Ames. Third season under observation.

This area in 1932-33 wintered a population of 96 quail in 7 coveys. In 1933-34, the population could not be fully censused, but there were at least 58 birds resident on Feb. 27. In 1934-35, the initial population for late November was established at 72 birds, of which but 9 were still on the area by March.

The cause of this very severe decline is not known, but in the main it probably represents either egress or illegal trapping on the outskirts of Ames. Although the area was very carefully worked all winter, remains of only 5 dead birds were found. Of these, two had evidently been killed by Cooper's hawks in late fall, and one by a barred owl *(Strix varia)*, and one possibly by a fox.

Food conditions were good, and the birds fed principally on corn and to a lesser degree upon soy beans and the seeds of a mallow *(Hibiscus trionum)*. The small population of from eight to a dozen wintering pheasants probably had no competitive status at all.

Group I—Nov. 22, 33 birds (7+1+14+11); Dec. 2, 27 (?) (8+11+10 (?); Dec. 16, 25 (10+6+9); Jan. 23, 14 (9+5); Feb. 2, 13 (4+2+7); Feb. 10, 7+ influx of 10 from Group II; Mar. 1, 7 (the 10 from Group II had left shortly).

Group II—Nov. 24, 39 (15+11+13); by Dec. 3 one covey had apparently left the area, leaving 28 (10+8+3+7); by Dec. 14 a probable influx from Group I brought the total up to 33 (7+10+16). On Jan. 11 there were 21 birds (8+13); Jan. 26, 13; Feb. 10, 2+10 moving out; Mar. 2, 2; Mar. 7, 2; Mar. 9, 2.

Thus may be depicted one of the most baffling enigmas that I have ever encountered in the course of intensive winter quail studies. There seemed to be no apparent reason why well-situated quail should dwindle as they did, and particularly with so little sign of dead birds. But they surely did dwindle, nevertheless, though not necessarily through mortality.

Area "J"—Area of perhaps 4000 acres along Squaw Creek, north and west of Ames. First season under observation, except for the 500 acres occupied by Group II, which has been studied for three winters.

The area may be said to have had a population near 153 birds at the beginning of December; a final population of 55 by the fore part of March. Thereafter the coveys had split and drifted so much that no counts which were at all reliable could be made.

Tracking conditions were exceptionally good for central Iowa this season, and I should judge the field work on this area to be the most thorough that I have ever done. The area was readily accessible and was easily blocked off

into well marked tracts for the convenient censusing of covey groups. The habitable quail environment, furthermore, was for the most part restricted to a strip of land rarely extending away from the creek more than a half mile in any direction.

For food, the quail population relied mainly upon corn, although most of the coveys relished the seeds of hemp *(Canabis)* of the creek bottomlands as long as such was to be had. The food supply, with noted exceptions, was adequate.

The December snow resulted in some starvation and considerable movement. The ice-glaze of late January was attended by a crisis which passed, however, with little immediate mortality, though it may have, by reducing the weight of some birds past the point of rapid recovery, been instrumental in bringing about later losses (Errington, unpublished manuscript). But in actuality, while the thickly ice-sealed corn remained for a few days unyielding to the efforts of hungry quail alone, many ears were soon opened by the gnawing or pecking of rabbits, squirrels, and crows. Pheasants were present in small numbers, and made some frozen corn available to quail also.

Group I—There were on Nov. 27, 32 (?) birds (12+20 (?)); Dec. 5, 8+3+20 (?). The three birds which had apparently split off from the original 12, moved away by themselves. They were reduced to one by January 2, and then this lone survivor disappeared. The covey of 8 maintained its numbers until two of its members seemingly joined the larger but not exactly censused neighboring covey. On Jan. 20, the count was 6+22; then there seemed to be continued interchange between the larger and the smaller coveys, which were using the same corn field. The smaller covey was finally no longer to be found, and the last count of the larger was 19 on Mar 7.

Remains of one bird dead from an unknown cause were found in the cornfield in which the larger covey spent practically all of its time. At least two quail had been eaten by horned owls in the early part of the winter, and a recent kill by a barred owl was found Mar. 31.

Group II—The territory occupied by this group was made virtually uninhabitable for the season by the fall plowing of a large cultivated field, and by the consequent destruction of almost the entire food supply. There were, as nearly as could be determined, 39 birds (11+13+15) on Nov. 4; 30+1 on Nov. 27. By Nov. 29, only 10 birds remained, and these may have been outsiders from Group III. The majority of the missing birds had apparently moved toward the territory of Group IV. On Dec. 5, 10+9 were present, evidently the whole of Group III, on the basis of their track trails both in and out of the territory. On Dec. 9, there were 7, of which one was collected for examination; Jan. 2, 6; Jan. 15, 4; gone thereafter.

Group III—No exact censuses were obtained prior to Dec. 10, but by mid-November a covey of about 18 was known to have occupied the coniferous grove and the unpicked cornfield which made up the regular range of this group. On Dec. 10 there were 10 birds which were shown by track trails to

have returned from Group II. As Group II lost birds, Group III gained, as the counts illustrate: Jan. 19, 12 birds; Jan. 24, 18 (including 2, presumably from outside). One more came in by Jan. 25, but the count was again 18 (15+3) by Feb. 12. The three birds seemed to split off permanently, and no trace of them was found again; they may have gone back to an outside covey from which it was suspected that they had originally come. The remaining 15 had dropped to 14 by Feb. 22; to 13 by Mar. 7. There was evidence of 2 quail having been killed by either horned or barred owls.

Group IV—The range discussed in connection with this group seemed to be vacant or nearly so for most of the fall. It was strong in food (corn) but a little unattractive as concerned cover. Shortly after the egress of the main Group II population, a substantial number of birds were discovered here, probably a recent influx.

On Dec. 10, there were 32 (in combination as 14+18 and as 13+19); and on Jan. 22, 31 (10+8+13). The covey of 10 maintained itself unchanged in numbers and in position until Mar. 7, but the others did not fare so well. Some of the others doubtless left the territory, but one covey of 5 was known to lose two birds in two days (Feb. 26 and 27).

These two birds had been plainly in bad shape. One had been killed by a redtailed hawk *(Buteo borealis)* while weakly fluttering over the snow; the other had died on its night roost, to be eaten by crows. One of the three surviving by Mar. 7 was collected and found to be in excellent condition—wt., 204 g.

By Mar. 23, the 9 survivors of the covey of 10 had apparently moved into a previously vacant territory which they had occasionally visited during the winter.

Group V—The environment which constituted the general range of this group of coveys was quite diverse in nature, and was made up of both uplands and lowlands. Corn was the chief staple food, although early in the season the birds fed much more on hemp and the achenes of lesser ragweed.

A census of 58 bob-whites (14+19+11+14) was secured on Dec. 7; Dec. 12, 55 (13+17+11+14). One covey had disappeared by Jan. 21, and the population count obtained was 37 (14+11+12); by Feb. 28 there were 35 (18+4+7+6, of which the last two coveys were near the edge of the area). On Mar. 8, only 12 (8+3+1) could be found.

The greater part of the decrease in this case was almost unquestionably due to egress, but some mortality was definitely ascertained. One bird died by itself in the snow and was later dug out in frozen condition by a mink. Remains of another bird were found under conditions which pointed to death from non-predaceous causes. Several, however, were known to have been killed by horned owls.

Group VI—The quail of this group had access to little food except the seeds of wild hemp. This supply became covered with snow and proved to be entirely insufficient for them and a small flock of mourning doves which tried to winter on a hemp diet (Errington 1935c).

The first count, on Dec. 8, was of 16 birds (12+4 which joined the larger covey in the course of the day). When flushed, 15 flew, and one, too weak to fly, escaped by running. On Dec. 11, remains of three dead were found (two on roosts), and there were 13 alive. On Jan. 7, there were 8 alive, and remains of three dead were found, including one, with a crop full of hemp seeds, which had been caught by a redtailed hawk. Four were alive on Jan. 21; 3, Jan. 30. On the latter date, fresh remains were found of a bird which had been scavenged upon by a fox. Old remains were also found upon a night roost. No sign of live quail was to be detected in the territory from Jan. 30 to the end of winter. Old remains of another dead quail were run across later.

The data from Group VI demonstrate what can happen to an ill-situated covey in times of food failure. The observational work was done with extreme care, and, for the 13 birds which disappeared before the last three apparently left the area, remains corresponding to 9 were located.

Area "K"—Sample area of about 300 acres, Des Moines Waterworks Supply Grounds. Third season under observation.

The area is a wildlife refuge which is adjoined by cultivated land but is not itself under cultivation. Consequently, from the standpoint of winter food for bob-white, the area away from its boundaries tends to be deficient because of natural plant succession, unless food is supplied artificially. This is commonly done by means of corn shock feeding stations attended by Waterworks employes. The cover conditions on the observational sample were excellent, and the birds are rigidly protected from poaching.

For the season 1933-34, the cover as it now stands was adequately supplied with food, and the winter survival of bob-whites was very close to 100 birds. In the fall of 1934, by request, the Waterworks withheld its feeding program on the sample area, in order that the reactions of the quail population might be observed.

The first census of about 60 birds (19+12+5+15 (?) +9) was obtained on Nov. 23. At this time the population was distributed rather widely over the area, and the birds were plainly feeling the shortage of food. One covey was scratching about one of last winter's feeding stations; one was in a cornfield adjacent to the area; and three coveys were eking out a precarious living upon the sparse growths of pigeon grass *(Setaria)* and the occasional tangles of climbing false buckwheat *(Polygonum)* to be found.

The check on Dec. 4 gave about 62 birds (10+8+ 5+8+17+14) on the area,, including a covey of 14 which appeared merely to pass through one corner. The main population was becoming pressed for food still more. One bird which had apparently starved was found, and two coveys showed sluggishness when flushed. These had been feeding on seeds of lamb's quarters *(Chenopodium)*, the fast diminishing supply of climbing false buckwheat, and upon the fruits of coralberry *(Symphoricarpos)*. (It may be remarked that fruits of fleshy or pulpy consistency have usually proved lacking in sus-

tentative value as staple winter foods for bob-white—during the cold weather the birds require foods of substance such as corn, wheat, soybeans, etc.)

The population reached its low ebb (15+11+5) for the season by Jan. 15, by which time the feeding program had been resumed. These birds were more or less concentrated in the strongest territory, and the rest of the area was quail-vacant. By Feb. 9, there were 32 (9+11+12), a gain of one; by Mar. 1, a gain of another (9+12+12).

Area "L"—Sample area of about 500 acres, Ft. Des Moines (U. S. Army property). Third season under observation.

The sample area is composed about half of cleared and tillable land which has been withdrawn from cultivation for three years. After the first season removed from cultivation, the plant succession became distinctly unfavorable for quail-food plants, but the summer of 1934 produced a bountiful crop of lesser ragweed. The ragweed was supplemented by planted food patches and by feeding stations maintained expressly for quail.

The improved food situation obviously made a tremendous difference to the wintering bob-white population. Whereas the population wintering on the sample area was only 24 by Feb. 27, 1934, an excellent census showed a population of 65 (11+15+10+14+9+6) on Feb. 8, 1935.

No accurate census was possible earlier in the winter of 1935, but a survey of the occupied territories on Jan. 4 gave an approximate figure of 78. On this visit there were to be found remains of four quail, evidently killed by predators. During the winter, great horned owls were known to have exterted considerable pressure upon what apparently constituted something of an over-population of bob-whites for the accommodation capacity of the area.

Area "M"—Sample area of about 500 acres, Ledges State Park and environs, Boone. Second season under observation.

Group I—Dec. 18, 11+7; Jan. 27, 10+6; Mar. 2, 10+6. One bird was killed by a hawk of unknown species. These coveys regularly frequented an excellent combination of food and cover—brush piles in which scratch feed had been placed by Park employes.

Group II—This group represents the birds of two widely separated coveys on private farmland adjacent to the Park. The data are treated together for the sake of convenience, as both coveys had access to good cover and the same types of food (corn, pigeon grass, ragweed, smartweeds).

The first visit was made on Feb. 4, almost too late in the season to get any wintering data at all. Old remains of one dead bird were found, and two coveys, each of 11. By Mar. 2 there were still 11 in one covey, but the other had lost a bird.

Area "N"—Area of about one square mile near Story City. First season observed.

Only a corner of the section was occupied by bob-whites, largely because

of lack of brushy escape cover. The cover on the occupied quarter had suffered much from grazing, but occasional brush piles, thickets, and vine tangles were of distinct value in making the land quail-habitable.

The first census on Jan. 6 gave 23 birds (11+12), and weathered remains of two dead birds were found. By Jan. 29, a covey of 15 had come in from outside the area. The final count gave 31 birds (14+12+5). Remains of one bird dead from an unknown cause were discovered during the winter observations.

South-Central Wisconsin

Area "O"—Area of five square miles east of Prairie du Sac. Sixth consecutive season under observation.

The data from this Wisconsin area are of special pertinence in that they illustrate heavy losses and attendant complications brought on by starvation and storm. Prairie du Sac exemplifies the mechanism of what we may call an ordinary "killing winter," of the sort which now and then drastically reduces bob-white populations in north-central states.

The area had a previously ascertained winter carrying capacity of around 330 birds, when the regularly frequented covey territories were adequately supplied with food. The 1934-35 snows not only covered up much of the food which would otherwise have been available and thus precipitated a crisis, but the food crisis in turn evicted coveys from regular territories and forced them to over-populate the restricted environment which was still habitable.

Over-population of the still habitable environment was followed by an acceleration of predation which cut the winter population down to those levels of accommodation characteristic of each territory or group of territories. In other words, the habitable, completely filled territories wintered approximately their usual number, and the birds (or their equivalent) that came in to exceed that number were lost. This was precisely what could have been predicted in advance, on the basis of the work which has been done in previous years (Errington 1934, 1935a).

The census figures were secured for Iowa State College largely by Mr. A. J. Gastrow, a resident of Prairie du Sac who for several winters has had the area under similar observation. He spent an average of three days per week in the field from Nov. 10 to Mar. 27. The initial quail population for about the middle of November was computed from the census data to be 411 birds. The Prairie du Sac birds were under observation for an average of 107 days, during which time a decrease of 215 was recorded, exclusive of 8 birds which came into the area during the course of the winter. Of the 215 birds decrease from the original 411, 39 and possibly more evidently left the area.

The mortality suffered by the resident coveys may then be placed at 176. The loss of 21 of these was attributed on fair evidence to starvation following sleet in January, and 40 more to the blizzard of Feb. 27. The balance of the very probable mortality—105 birds—represented predation which was in large

measure intensified by over-crowding in the better habitats. The great horned owl was the chief enemy to which depredations were traced.

Group I—Nov. 10, 24 birds (12+12); Nov. 27, 23 (11+12); Dec. 5, 23; Dec. 13, 24 (15+9); Dec. 28, 22; Jan. 18, 22 (14+8, of which the latter covey went to the range of Group II); Jan. 28, 29 (10+12+7, the latter covey of which came in from Group XV); Feb. 6, 45 (16+19 from XV and 10 now near II); Feb. 23, 28 (17+11); Mar. 25, 28 (?) (16+12 (?)). Loss of 19; gain of 23; net gain of 4 in 134 days.

The birds of Group I relied principally upon corn in the shock. They also fed occasionally on the beans fallen from a patch of black locusts. Altogether, the food conditions in the territories occupied by these birds were superior and served to draw in coveys or covey remnants from less congenial situations; however, the resulting over-populations were usually relieved rather promptly by the egress of either the new-comers or their equivalent number.

Group II—Nov. 10, 33 (?) birds (16+17 (?)); Dec. 1, 42 (16+17+9 from I); Dec. 26, 41 (26+15); Jan. 7, 61 (?) (18+15+8 (?) +20 birds influx from III); Jan. 18, 61 (18+8+15+20); Jan. 30, 46 (19+12+15); Feb. 6, 44 (19+15+10); Mar. 1, 33 (25+8) and evidence of two kills; Mar. 18, 37 (25+12, with a probable influx from XV). Loss of 29; gain of 33; net gain of 4 in 127 days.

The principal foods were corn, soybeans, and acorns chewed by hogs.

Group III—By the first of December there were about 20 birds in the territory; by January 7 they had gone to II. Territory totally vacated in 37 days.

Group IV—Nov. 24 and Dec. 1, 62 birds (14+14+12+23); Dec. 10, 62 (14+14+15+19); Dec. 19, 60 (5+22+14+19); Jan. 5, 56 (21+13+16+6) and evidence of a few kills; Feb. 2 and 6, 44 (8+6+17+13); Feb. 17, 43 (10+6+16+11); Mar. 3, 39 (6+5+12+16); Mar. 20, 35 (6+16+13). Net loss of 28 in 115 days.

Group V—Nov. 20, 27 birds (15+12); Dec. 13 and Jan. 2, the same; Jan. 28, 23 (14+9); Feb. 9, 21 (11+10); Mar. 25, 0. A few birds were lost from predation early in the winter; then, the whole population was wiped out by the late February blizzard. There was much evidence of mortality to be found after the snow had melted. Net loss of 27 birds in 134 days.

Group VI—Nov. 24, 17; Dec. 22, 19 (some probable influx from VII); Jan. 27, 7 (probable egress of 7 or more to IX); Feb. 6, 6; Feb. 21, 0. Loss of 19; gain of 2; net loss of 17 in 88 days.

Group VI occupied a territory which has been consistently uninhabitable for quail during the six seasons that it has been kept under observation. Lack of cover seemed to be the primary defect of the territory, though the food supply (corn and soybeans) is usually good enough to attract ill-situated birds that may happen to discover it.

Group VII—Nov. 14, 14 birds; Dec. 17, 21 (with a probable influx of 7 from VIII); Jan. 25, 18 (11+7); Feb. 6, 19 (10+9); Mar. 22, probably the same. Loss of 3; gain of 8; net gain of 5 in 127 days.

Group VIII—Nov. 14, 18 birds; Nov. 22, 17; Dec. 13, 10 (probable egress of 7 to VII); Dec. 19, 10; Dec. 24, 15 (influx probably from XI); Jan. 7, 14; Jan. 18, 10; Feb. 4, 7; Feb. 14, 6; Mar. 1, 4; Mar. 20, 1. Loss of 22; gain of 5; net loss of 17 in 125 days.

Group VIII represented a badly situated covey which was forced into a farmyard by food shortage. The cover adjacent to the farmyard was poor, and it is suspected that much of the mortality was due to house cats.

Group IX—Dec. 7, 24 birds (14+10); Dec. 17, 22; Dec. 31, 13 (one probably lost from the original covey of 14; the others seemingly moved out of the area); Jan. 25, 20 (probable influx of 7 or more from VI); Feb. 6, 16; Feb. 21, 15; Mar. 27, 14. Loss of 17; gain of 7; net loss of 10 birds in 109 days.

Group X—Nov. 14, 27 birds; Dec. 31, 27 (19+8); Jan. 25, 24; Feb. 6, 20; Feb. 21, 18; Mar. 22, 16. Net loss of 11 in 121 days.

Group XI—Nov. 10, 27 birds (14+13); Nov. 24, probably the same; Dec. 15, 24 and the evidence of two kills; Dec. 22, 21 (some probably went to VIII); Jan. 7, 22; Feb. 6, 18; Feb. 19, 16 and one killed by a steel trap; Mar. 6, 13; Mar. 18, 12. Loss of 16; gain of 1; net loss of 15 in 127 days.

Group XII—Dec. 1, 12 birds; Dec. 15, 8 and evidence of kills; Jan. 7, 0 and evidence of two more kills. Net loss of 12 in 37 days.

Group XIII—Dec. 1, probably 14 birds; Jan. 10, 14; Jan. 30, 0. Net loss of 14 in 60 days through departure from area.

Group XIV—Dec. 5, 57 birds (10+12+15+20); Dec. 22, 57 (11+34+12); Jan. 30, 52 (11+18+14+9); Feb. 6, 51 (?) (15+12+8+5+11 (?)); Mar. 1, 36 (11+10+15—loss mainly due to egress from area); Mar. 18, 34 (11+23). Net loss of 23 in 102 days, chiefly through egress.

Group XV—Dec. 3, 34 birds (14+20); Dec. 28, 42 (21+21, probably including influx from outside the area); Jan. 13, 39; Jan. 27, 30 (16+14) and considerable evidence of mortality; Feb. 6, 10 (19 apparently went temporarily to I); Feb. 23, 13 (some apparently returned from I); Mar. 6, 0. Loss of 42; gain of 8; net loss of 34 in 92 days.

Discussion

In the analysis of the decline shown by the bob-white populations on the 1934-35 winter observational areas, separation of mortality losses from losses due simply to departure may be possible to some extent.

Many of the disappearances of Iowa coveys without evidence of mortality were baffling in every way. Birds just disappeared, and that was the last anyone ever heard of them. Illicit trapping would have produced this effect, and trapping doubtless may occur locally now and then, but the covey disappear-

ances were noted and reported with such uniformity over central and southern Iowa that trapping as a general explanation may be ruled out. Shooting may have been responsible for the dwindling of certain coveys also, but pressure of this type on any large scale is usually betrayed by a little evidence as to what may be happening; shot-up coveys become very wary of man, and an investigator engaged in intensive field work should encounter a few birds wounded or not recovered by the shooters.

That disease may have played a part in the winter decline is entirely likely, although evaluation of that possible factor presents difficulties. Hamerstrom found dead under the snow an adult bob-white with a massive infection of coccidia. The weakened condition of two birds of one of the Ames covey remnants (Area "J," Group IV) may be indicative of disease since the other birds of the covey were of good strength. Starker Leopold and Arthur Hawkins noted birds of mixed poor and excellent condition in some of the Wisconsin coveys which they were observing (unpublished). Green and Wade (1929) found tularemia in a wild bob-white captured in a helpless condition at the outskirts of Minneapolis on February 17 and suspect that this disease was probably responsible for the loss of a diminishing covey.

Other questions, at present unanswerable, arise when one considers the possibility of the decrease of quail being associated in some way with the imperfectly understood cyclic (periodic) declines suffered by various grouse, rabbits, rodents, and other animal populations (Leopold 1933, pp. 59-71; Wing 1935). Irregular fluctuations of bob-whites in response to natural cataclysms such as wholesale starvation have been recorded, but these fluctuations have long been thought non-cyclic. There are indications, however, which hint that the population levels of that species may fluctuate periodically as well as irregularly.

But decline of populations from disease or anything else which implies a wholesale die-off of birds in the wild would hardly take place without leaving some tangible evidence, as a sprinkling of carcasses and feather remains, a substantial proportion of which could be found by careful search. Most of the disappearances of Iowa coveys were accompanied by little sign of mortality, in contrast to the voluminous evidence found when coveys were known to have starved or to have suffered severely from predation.

The logical deduction is that most of the disappearances of coveys did not represent mortality at all, at least not mortality while the birds were on the observational areas. This view is partially substantiated by the findings of coveys in unusual places, particularly in late winter. A number of coveys which seemed to have disappeared were found, after diligent search, to be stationed for days at a time in the centers of large cornfields hundreds of yards from their favored coverts. The moving of other coveys entirely off the observational areas was traced in a few instances. However, far more quail left the areas than were noted to have come in.

Does such consistent failure for influx to compensate for egress mean mortality? Doubtless some mortality had attended these movements, for move-

ment itself frequently denotes insecurity. On the other hand, it seems more probable that, with the moderating of the weather in February, some of the surviving population may simply have spread into environment uninhabitable to them in the dead of winter. One covey of 8 was found on April 8 in open farming country remote from any brushy cover and at least a mile from any known winter habitat.

Heavy predation upon wintering adult bob-whites, as for previous seasons (Errington 1934; 1935a), seemed contingent upon physical weakness of the quail themselves or upon the extent to which they over-populated their habitable environment. During the most open of winters, and under stable conditions of agriculture, a given tract of land appears to have a remarkably definite carrying capacity in respect to the number of quail which can be accommodated. Carrying capacity sets the *upper limit* of survival, to which populations in excess of that limit will be reduced. It does not, however, insure the survival of that number.

Predator populations of varying compositions have been noted on all of the areas under observation, but these data will not be presented in detail here. Suffice it to say that very heavy predator populations as well as light ones have been studied, yet the severity of bob-white winter losses from predation seems *not* to be correlated with the kinds and numbers of resident predators. This applies also to populations of great horned owls and red foxes, to which the bulk of the known 1934-35 depredations have been traced.

If the quail themselves were weak or individually handicapped, they were vulnerable to predation, whether the predators were few or many, clumsy or skillful. If quail tried to winter in numbers exceeding the capacity which their ranges were known to be able to accommodate with security, the birds in excess of the carrying capacity were likewise vulnerable and were eliminated in one way or another by spring.

The minimal requirement for security of wintering bob-white populations in north-central states is still fitness, both of individual and environment. There may be other significant factors to obscure the equation, and these may still be unevaluated or even of unguessed nature. But while we may never expect our ecological picture to be complete, a few more details have been added to the pattern, and a few of the older ones have been made clear.

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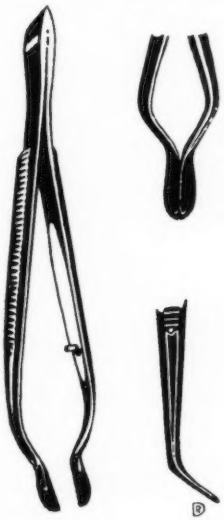
Notes and Discussions

New Herbarium Mounting Forceps

When mounting plants for the herbarium it is generally necessary to supplement the adhesive by bridging stems and other parts likely to break loose with strips of gummed cloth. To fasten the plant to the sheet most effectively these strips should be attached firmly about the stem and fastened to the paper close to the plant part. If the strip slopes from the stem tent-wise before adhering to the paper the plant is more easily loosened and the strip fails to perform its function properly.



Ordinarily the strips are attached with the aid of laboratory forceps and pressed down with the ends of the forceps, a scalpel, or some other implement. In general, however, these do not function efficiently or satisfactorily. We have tried different types of forceps in an attempt to discover one that would do this work to better advantage but none on the market is of the proper shape.

Recently we shaped a pair of ordinary laboratory forceps to make what has proven to be a very decided improvement on any yet used. They have been found to increase greatly the ease and speed of the operation. With these improved forceps the gummed strips are easily placed about and beneath the stem and attached firmly to it as well as to the paper thus making an efficient reinforcement. The success we have had with this gadget prompts us to present a sketch and this description of it hoping that the idea may prove of value to others having a similar problem.

Ordinary 5-inch, curved-end, dissecting forceps were used. They were heated and then shaped. The lower part should be curved to go about stems, etc., and the tips flattened and bent to the proper angle. The other end of the forceps was squared and sharpened as a chisel which serves for scraping off pieces of excess paste, paper, etc., as well as aiding in attaching strips about large objects.—T. G. YUNCKER.

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Book Reviews

THE SOLAR SYSTEM AND ITS ORIGIN, by Henry Norris Russell. New York: The Macmillan Company, 1935. viii + 144 pp. $2.00.

WORLDS WITHOUT END, by H. Spencer Jones. New York: The Macmillan Company, 1935. xv + 329 pp. $3.00.

Disputes of rival adherents to varied hypotheses of earth origin (which involves also the origin of the solar system itself) have made necessary an impartial and non-technical statement of evidence and opinions. This Dr. Russell has provided in a small book that is both solid and pleasantly readable.

It begins with a survey of the dynamical, physical and chemical properties of the solar system. There is special emphasis on comets, which depart so far from that system as a whole that they appear to be late captures from a nebula or diffuse cloud, through which the sun passed. Weight is given Bobrovnikoff's suggestion that this occurred as recently as a million years ago.

Physical and chemical properties are found to be harmonious with any hypothesis which supposes that planets and smaller bodies were "removed from an intensely heated surface similar in composition to the outer parts of the Sun, and allowed to cool rapidly." The Laplactian hypothesis therefore is discarded, and attention is concentrated on the hypotheses proposed by Chamberlin and Moulton, and by Jeans and Jeffreys. Readers who have been hard pressed to find the gulf between them that some partisans have described will be reassured to learn that, in Dr. Russell's opinion, it does not exist. He fully accepts neither, introducing data which modify both conceptions and suggest the future development of others in line with the universes of physics. Which universe, is not stated; after the assurance of Eddington and Jeans, such reticence is welcome.

A kindred reserve marks *Worlds Without End*, by the British Astronomer Royal. In a large measure, this small and well-written book will provide a cosmic background for Russell's volume. It also will meet the needs of those who want a survey of the astronomical world without either the technicalities of astronomy or constant "interpretation" in the light of some favored philosophy. Too much of that has been poured into popular thought during the past ten years. A book that steers an unbiased, informative and thoroughly interesting course through the materials of the universe therefore is welcome.—C. L. FENTON.

MONTANA: THE GEOLOGICAL STORY, by Daniel E. Willard. The author, Railway Building, St. Paul, 1935. 373 pp., 122 figs. $2.50 postpaid.

Twenty years ago, the U. S. Geological Survey began publication of guidebooks for travelers in the West. In each of the seven volumes issued, a railway route is selected and described, with strip maps, drawings and photographs. There is no general statement of principles, the reader being expected to know them. There also is slight concession to what most of us consider an attractive book, either in style or format. Most of the users therefore are geologists.

Mr. Willard does not wish his audience to be so limited. He has assumed that his readers know little or nothing of geology, and in a series of introductory chapters has presented basic processes and principles as they apply to the state of Montana. Since that state contains plains, valleys of several types, and varied mountains, he has an almost unlimited field.

These chapters on stream action, erosional cycles, glaciation, rock types and kindred topics are followed by others describing regions of special scenic interest in which earth

processes are conspicuously shown. The Yellowstone region is used to illustrate vulcanism, Glacier National Park to show faulting, Butte as an example of igneous mineralization, and so on. Most successful of the lot are the chapters on the glacial Lake Missoula and the Yellowstone. That on coal gives a clear idea of Montana's enormous resources and mines, but fails to present convincingly the conditions under which seams as much as twenty-eight feet thick accumulated. The layman wants to know actual steps in the process, and even the geologist would like a summary of ecologic and geographic conditions during the Cretaceous and early Tertiary epochs of coal deposition.

The last five chapters apply facts of the preceding twenty to travel along major railways and roads. Here the treatment compares with that in the official guides (none of which treats Montana), but is brief. Perhaps too brief, despite the fact that all essentials of pure geology already have been stated.

Physically, too, this volume avoids defects in the Geological Survey's books. It is attractively printed on good paper. The abundant photographs are carefully selected and appear close to the descriptive text. Even the binding invites one to use Mr. Willard's book, for it is exceptionally attractive.

Yet it seems, to this reviewer at least, that the user will not be quite satisfied and in some places may be seriously confused. In part this will result from the style, which is not technical yet is hard to read. Unity commonly is sacrificed to simplicity of sentences, whose connection is not readily apparent. The geologist supplies it—but will the layman?

More serious is a lack of narrative in treatment of events and processes, coupled with absence of simple diagrams and diagram maps. There is not even a sketch map of Montana in the book, nor a relief diagram. Laccoliths are mentioned but not illustrated, nothing illustrates the actual processes and events of intrusion, extrusion and kindred phenomena. The diagram of faulting in the region of Glacier Park is very simple: neither it nor photographs give an adequate picture of the events involved in the Lewis Thrust. As for the history of the Flaxville Plain: it is dramatic and absorbing when encountered on the ground, but the book fails to visualize it.

Finally, by slighting the processes of sedimentation, the author has lost another opportunity to dramatize events of the geologic past, to explain abundant and often exceptionally attractive rocks, and to round out his story of Montana. This loss is specially obvious in his treatment of the Belt Series, which shows—better than most later rocks—the factors operating during deposition. In the reviewer's experience, these records of sleet and rain storms, of floods, of seasonal changes in temperature, moisture and light, of storms and periods of drying, interest the layman quite as much as faulting or glaciation. That they are about 600,000,000 years old reenforces their lesson of uniformitarianism.

In short, while this is a needed and useful book, it still falls short of a satisfying travel guide to geology in a state which justifies the author's enthusiasm. When such a guide is written, it probably will combine some elements of Reed's excellent *Earth for Sam*, of Wilfrid Bronson's scientific cartoons, of Fenneman's *Physiography of the Western United States*, and of pure travel books, with the plan of Mr. Willard's volume and its abundant data. Then publishers probably will refuse it because "the public is not interested in the earth," and the author will lack Mr. Willard's courage to publish —well—for himself.—C. L. FENTON.

WEST COAST SHELLS, by Josiah Keep. Revised by Joshua L. Baily, Jr. Stanford University Press, 1935. xii + 350 pp., 334 figs. $3.75.

This fifth edition of a standard semi-popular work maintains the standards and style established by Professor Keep when he first published it in 1887. It also meets a definite need, for despite the work of Dall, the Oldroyds, S. S. Berry and others, there remains a dearth of information on Pacific Coast molluscs.

The present work deals with both molluscs and brachiopods. Mr. Baily has brought nomenclature and descriptions up to date, has incorporated data on habits and habitats as well as ranges, and by keeping all to a minimum has managed to include a very large number of species in a book of small bulk. He also has retained appeal to amateur conchologists by introducing a small amount of anecdote and some continuity and informality into the descriptions. Yet, so far as can be determined in the study, these are adequate and convenient for ordinary identification.

Illustrations are less satisfying. Most of these are in line and are reprintings from cuts in the edition of 1911. Some are crudely and inaccurately drawn, as in Figs. 34 and 93; others are so small or so dark that they have printed as little more than blots, of slight help to the student. That the fault lies with the drawings is obvious to any illustrator, and is emphasized by the fact that paper and presswork are excellent.—C. L. FENTON.

SINGING IN THE WILDERNESS, a Salute to John James Audubon, by Donald Culross Peattie. G. P. Putnam's Sons, New York, 1935. 245 pp. $2.50.

This work is a charming bit of literature dealing with the life of the great Audubon, written in narrative form as the author conceived the life of Audubon to have been. It is fascinatingly written, one hates to lay down the volume once he has started to read it. The author has probably taken a few poetic licenses, yet the work is well done and apparently authoritative. The sources of his information are listed at the end of the volume, chief among them being Herrick's Audubon the Naturalist. The volume is embellished with a half dozen reproductions of Audubon's famous Plates, one of them, the Baltimore Oriole, done in color. Facing page 116 is a hitherto unpublished likeness of the artist done by himself as a miniature. All those interested in the life of this great naturalist will find the book well worth reading, particularly those who live in the Mississippi Valley region where Audubon did so much of his work. —MARCUS WARD LYON, JR.

THE ALGAE AND THEIR LIFE RELATIONS, by Josephine E. Tilden. University of Minnesota Press. 1935. xii+550 pp., 9 pls., 257 figs., 1 chart in color.

The object in preparing the present volume, according to the author, has been to offer to teachers and students material arranged in orderly fashion, on the basis of which any desired course may be planned. It is apparent, however, that a second, and equally important purpose has been realized, that of giving expression to mature personal convictions concerning the life relationships of algae by one whose experience in this field of study makes these personal convictions of value to all students of algae.

The first three chapters have to do with the classification and phylogeny of algae and include much of a highly controversial nature. Five classes of algae are recognized by the author. These are considered as having had a parallel development rather than the "family-tree" type of relationship. These classes are: *Cyanophyceae, Rhodophyceae, Phaeophyceae, Chrysophyceae and Chlorophyceae.* These classes are considered as being radically different from each other especially as regards pigmentation. The author suggests that the various pigments involved were originally called into existence in response to certain environmental forces or variables, the most important being illumination. The concept of a gradual increase in quantity of solar illumination, or a change in quality, in early geological periods is essential to the author's scheme of algal phylogeny. The best functioning of the chlorophyll of each algal group, which is assumed to have been present, was possible in the varying degrees of illumination only in the presence of certain other pigments which now characterize these groups. For instance, the *Cyanophyceae*, which are assumed to have made their appearance before any other algal group, appeared in a geological period when there

was but a slight degree of light penetration. Consequently the chlorophyll in the cells of the blue-green alga was able to function in this feeble illumination only in the presence of, or with the assistance of, a second pigment, *phycocyanin*. A similar situation is found in connection with the *Rhodophyceae*, *Phaeophyceae* and *Chrysophyceae*, each group making its appearance in successively later geological periods with an ever increasing solar illumination. The *Chlorophyceae* are plants essentially of sunlight and are usually without a second pigment.

A geological time chart (Pl.I) indicating the points of origin and possible sequence of algae and other plant and animal groups cannot fail to meet with objections common to the majority of similar efforts. Particular attention might be called to the fact that there is a rather complete lack of plant remains in support of the chart which lists genera of all algal classes except the *Chlorophyceae* before the Cambrian.

Chapters four to eight inclusive, deal with the five recognized algal classes in considerable detail. Each chapter begins with a few pages of introductory material in which the author discusses theoretical problems of phylogeny and classification, or more immediate problems of phylogeny and classification, or more immediate problems of life history and structure, or, possibly, terminology. Elementary students may fail to grasp the correct picture of the class as a whole after having read these introductory pages. It is doubtful, for instance, that a fairly comprehensive view of the *Cyanophyceae* can be gained by a perusal of pp. 48-52, which form the introduction to the chapter dealing with the *Cyanophyceae*. On the other hand, and what may be of greater value, these pages are crowded with brief discussions of many questions, giving the author's views on many widely separated difficult topics.

The bulk of the text is made up of a systematic treatment of the algal groups down to genera. Species are indicated only in the numerous illustrations. No keys are included in the text, but brief diagnoses follow each sub-division from class to genus. The derivation of the generic name is also given. Following the diagnosis, the author frequently adds interesting notes as to recent researches, life history or natural history concerning the particular genus.

The systematic treatment of certain classes is of interest. The *Rhodophyceae* and *Phaeophyceae* are arranged along fairly conventional lines. The *Chrysophyceae*, however, include all algal groups in which there is an excess of xanthophyll present in the chromatophores, resulting in a yellow-green or golden brown coloring. The class *Chrysophyceae*, therefore, includes the following assemblage of sub-classes: *Tribonemeae*, *Diatomeae*, *Chrysomonadineae*, *Peridineae*, *Cryptomonadineae*, *Chloromonadineae*, *Euglenineae*. This is a logical grouping if one follows the author's general ideas of the phylogeny of algae. On any other basis this brings together organisms of a fairly wide divergence.

The Class *Chlorophyceae* is divided into three sub-classes, the *Uninucleatae*, the *Siphonocladae* and the *Siphonae*. The *Charales*, again are considered as plants of uncertain taxonomic position. The general relationships of the higher plants with the algae are indicated by the author in the following quotations: "While no actual proof can be presented, the author believes that ancestors of the present land plants had their origin in marine green algae which developed on the seashore. If this be true, the Siphonocladales, Siphonales, Charales, Pteridophyta, Gymnospermae and Angiospermae all evolved from a common green ancestor" (p. 357). And again, (p. 427), "The author believes that the Bryophyta represent the acme of specialization in the subclass Uninucleatae."—J. H. Hoskins.

VERGLEICHENDE MORPHOLOGIE DER HÖHEREN PFLANZEN, von Wilhelm Troll. Erster Band: Vegetationsorgane. 1. Lieferung, vi+172 pp., 104 figs. Berlin, Gebrüder Borntraeger, 1935. RM 12.00.

Recent years have witnessed the publication of several excellent morphological treatises of different plant groups covering lower as well as various higher forms. However botanists were in need of a comprehensive work on the morphology of higher

plants summarizing this widely scattered knowledge. The present work, the first instalment of which is now available is contemplated to remedy this condition.

The work is planned on a large scale and is to be finished in three volumes in the course of three years. While the Pteridophyta are to be included only as far as the vegetative organs are concerned the main of it will deal with the Spermatophyta. Vol. 1 is to contain the treatment of the vegetative organs only, while vols. 2 and 3 are reserved for that of the inflorescences, flower, fruit, and seed. If completed in this form the work will easily be the most modern and inclusive morphology of higher plants. Yet the work is highly original as regards both the interpretation of the available material as well as the new information incorporated. Its physical make-up is of the excellence expected in Borntraeger books.

The main theme of the introductory chapters, and for that matter of the whole work, is the restitution of the comparative morphological method which culminates in the concept of an "Urpflanze" as first visualized by Goethe. The author believes firmly that only through a revival of this method of typological comparison and its idealistic concepts of "types" can there come a re-birth of morphology. There are lengthy and fluent discussions on the nature of morphology, of morphology in relation to other branches of botanical investigation, i.e. the study of ontogeny and teratology, as well as experimental morphology, organography, and phylogeny. All of these chapters state precisely the aim of this recently revived school of morphology and are clearly illustrated by examples which are interpreted on the basis of its views. Thus much old material appears in a wholly new light and is consequently destined to stimulate botanical thought in more than one way.

The wide difference between the two schools of morphology is well expressed by H. Hamshaw Thomas in the title of his recent paper "The old morphology and the new." (Proc. Linn. Soc. London, Session 145, 1932-33, Pt. I). It is particularly the theory of descent and the influence it had and still has upon morphology that is the focus of discussion. Troll on the one hand denies the existence of a specifically phylogenetic method while Thomas in turn sees the "new morphology" advanced by taking "into consideration the evidence derived from the study of all aspects of plant-life." Or in brief "the general ideas of the new morphology . . . are based on considerations of phylogeny." Troll claims that the theory of descent may profit by recalling that it sprang from comparative morphology and that it is not descent which is decisive in morphology but vice versa: morphology has to decide about the possibility of descent. Such is the divergence of morphological views at present.—TH. JUST.

POLLEN GRAINS. Their structure, identification and significance in science and medicine, by R. P. Wodehouse. New York, McGraw-Hill Book Co., 1935. xv+574 pp., 123 figs., 14 pls., 6 tables. $6.00.

Two rather widely different lines of investigation have of late become more and more concentrated upon the morphology of the pollen grain—paleontological study of the pollen fossilized in peats and other deposits and medical science's concern with hayfever as caused by pollen. While the needs of these were kept in mind by the author he has not restricted his treatment to such phases but has presented us with the most complete treatise available in any language on the subject. The author has prepared most of the material and the greater part of the excellent illustrations for this volume giving proof of his extensive researches.

The book is divided into two parts. Part I is general in nature and reviews earlier work, acquaints the reader with methods for collecting pollen, its preparation for microscopic examination, hayfever, and pollen-grain characters. One chapter has been contributed by Prof. G. Erdtmann under the title "Pollen Statistics: a botanical and geological research method."

Part II is given over entirely to "Classification" and opens with a Master Key, a convenient form of summarizing the outstanding results of the detailed taxonomic accounts which make up its bulk. Both fossil and living Gymnosperms and Angio-

sperms are treated. This part should be of especial interest to taxonomists who have heretofore failed to avail themselves to any appreciable extent of the fine characters found in the pollen grains.

The volume fills an obvious gap in botanical literature and is bound to remain a standard for some time to come.—TH. JUST.

THE BEGINNINGS OF PLANT HYBRIDIZATION, by Conway Zirkle. Morris Arboretum Monographs I. Philadelphia, University of Pennsylvania Press, 1935. xiii+231 pp., 8 pls. $2.50.

All descriptions of plant hybrids prior to 1761 are here assembled for the first time and substantiated by many quotations and translations of pertinent passages. Even entire papers are reprinted since many of these old works are often quite inaccessible to modern geneticists. As a result a wealth of valuable historical information is thereby made available in a convenient form which should not only prove of interest to botanists and biologists but beyond such professional circles in general to historians of human thought. The many peculiar notions held to be true until very recently elucidate admirably the particular periods during which they were conceived. Mention is made of the work of various early botanists whose observations and experiments on hybridization had remained unnoticed. There is an appendix which includes a chronological list of hybridization between 1716-1760 and a comprehensive bibliography. The plates are well reproduced and represent either well chosen portraits or illustrate other objects of interest, e.g. first figures of segregation in *Zea Mays*. It is regrettable that its value is somewhat diminished by unfortunate typographic errors and incomplete citations.—TH. JUST.

THE SPECIES OF TRADESCANTIA INDIGENOUS TO THE UNITED STATES, by Edgar Anderson and Robert E. Woodson. Contributions from the Arnold Arboretum of Harvard University IX, Jamaica Plain, Mass., 1935. 312 pp., 12 pls. $2.25.

Tradescantia has played an important rôle in the development of modern botanical knowledge being one of the "types" studied in many laboratories and for diverse purposes. In presenting this revision the authors wisely restricted their treatment to the species occurring north of Mexico thereby limiting themselves to groups the area of which corresponds with but few exceptions to that chosen. The individual chapters consider a variety of data under such headings as "Taxonomic History, Gross Morphology, Speciation, Hybridization, Study Material, Taxonomy." A total of 22 species is treated, five of which are described as new and mostly from Missouri and neighboring states south and southwest. These are: *ozarkana*, *Ernestiana*, *Tharpii*, *paludosa*, and *longipes*. Not only was a wealth of herbarium material consulted but many plants were grown to secure genetic and cytological data. The plates are excellent and illustrate morphological details of various species as well as typical specimens of the new species. No doubt this timely revision will be a welcome addition to botanical libraries.—TH. JUST.

VEGETATION UND FLORA DES LUNGAU (SALZBURG), von Friedrich Vierhapper. Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, vol. 16, no. 1, Vienna, 1935. 289 pp., 1 map. Schilling 30.00.

At the time of his death in 1932, F. Vierhapper had practically completed this last work which may well be regarded as his life's work. H. Handel-Mazzetti saw it through the press and contributed a preface in which he reveals as a friend much of the man and botanist Vierhapper.

The monograph is divided into a sociological part given over to discussions of

topography, climate and phenology, soils, classification and description of vegetation types, while the second and by far the more extensive part is entirely taken up by a "Prodromus" of the vascular flora of the Lungau. It is in this part that a vast amount of detailed observation and intimate knowledge of plants found in the region has been carefully assembled. These data are for the greater part the result of numerous excursions by the author over a period of some 25 years. Such thorough acquaintance with a limited region, coupled with the carefulness of the author account for one of the best of recent studies of the flora and vegetation of any region in the eastern Alps. With the author one of the last of the famous school of Kerner von Marilaun has passed, while his work will remain as a model, which will be difficult of approach.—TH. JUST.

PROTOPLASM, by William Seifriz. New York, McGraw-Hill Book Co., 1936. x+584 pp., 179 figs. $6.00.

This is the last volume issued of the well-known "McGraw-Hill Publications in the Agricultural and Botanical Sciences." The author has assembled and carefully selected "all those parts of the branches of science which bear upon the physical chemistry of living matter." As a result a variety of topics, frequently of a controversial nature, has been treated, and the reader's interest sustained throughout the book by a lucid style which is purposely as non-technical as the subject will permit. Most of the illustrations are original, and all are well chosen. A bibliography at the end is arranged according to the chapters and purposes to assist in further studies.

Although intended primarily for the student of biology and medicine, the book has a wider appeal to a public needing an adequate and reliable guide through an embarrassingly large body of special literature. Readers will be indebted to Prof. Seifriz for this most opportune volume.—TH. JUST.

THE JOURNAL OF THE SOUTHERN APPALACHIAN BOTANICAL CLUB, published for the Club at West Virginia University, Morgantown, W. Va. Vol. 1, nos. 1 and 2, January and February 1936. 24 pp. $2.00.

The Southern Appalachian Botanical Club, formed late in 1935, claims to represent the interests of botanists of an area which comprises "all of the upland region south of the limits of Pleistocene glaciation, hence including southern Pennsylvania, western Maryland, and parts of all the States of West Virginia, North Carolina, South Carolina, Tennessee, Alabama, and Georgia." One of the main activities of the club which it shares with other regional clubs, each for its own territory, is the publication in this new journal of botanical papers. The papers thus far published are mainly taxonomic. There are lists of plants found in certain sections and new records, though other phases have not been neglected. A useful feature is the "Index of Appalachian Botanical Literature." There are also reports of meetings, and other matters of interest to local botanists.

This is the last of a series of American botanical journals recently established and devoted primarily to taxonomic and plant geographic problems. All this is evidence of a new and growing interest in this field of botanical endeavor.—TH. JUST.

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